BID DOCUMENTS COVER SHEET

CONTRACT DOCUMENTS

FOR

C-4016 New Science Building – Increment 2

AT

Contra Costa College
2600 Mission Bell Dr., San Pablo, CA 94806

CONTRA COSTA COMMUNITY COLLEGE DISTRICT

Consists of:

VOLUME 2 - Division 02 - 14

DSA File #7-C1
DSA Appl. #01-117149

Architect:
SmithGroup, Inc.
301 Battery Street, 7th Floor
San Francisco, CA 94111
415.227.0100

July 24, 2019
SECTION 00007
SEALS PAGE

ARCHITECT: SMITHGROUP
Chun-Kei J. Wong
301 Battery Street, 7th Floor
San Francisco, Ca 94111
(415) 227-0100

LANDSCAPE ARCHITECT RHA
Manuela King
225 Miller Ave.
Mill Valley, CA 94941
(415) 383-7900

CIVIL ENGINEER: BKF ENGINEERS
Dayne Johnson
1646 N. California Blvd, #400,
Walnut Creek, CA 94596
(925) 940-2200

LABORATORY PLANNING RESEARCH FACILITIES DESIGN
Richard M. Heinz
3965 Fifth Avenue, Suite 400
San Diego, CA 92103
(619) 297-0159

STRUCTURAL ENGINEER RUTHERFORD + CHEKENE
David Bleiman
375 Beale Street, Suite 310
San Francisco, CA 94105
(415) 568-4400
MECHANICAL ENGINEER
INTEGRAL GROUP
David Costello
427 13th Street
Oakland, CA 94611
(510) 663-2070

ELECTRICAL ENGINEER
INTEGRAL GROUP
Vish Mahajan
427 13th Street
Oakland, CA 94611
(510) 663-2070

FIRE PROTECTION ENGINEER
THE FIRE CONSULTANTS, INC.
John Stauder
1777 N. California Blvd., Suite 200
Walnut Creek, CA 94596
(925) 979-9993

TECHNOLOGY ENGINEER
TEECOM
Larry A. Anderson
1333 Broadway Suite 601
Oakland, CA 94612-1906
(510) 337-2800

END OF SECTION 00007
# SECTION 00010
## TABLE OF CONTENTS

**VOLUME 1 – DIVISIONS 00 - 01**

### DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS
- SECTION 00001 TITLE PAGE
- SECTION 00007 SEALS PAGE
- SECTION 00010 TABLE OF CONTENTS
- SECTION 00016 CCC COLLEGE COMPLEX MAP (Note Location for Pre-Bid Meeting)
- SECTION 00100 NOTICE INVITING BIDS
- SECTION 00200 INSTRUCTIONS TO BIDDERS
- SECTION 00210 INFORMATION AVAILABLE TO BIDDERS
- SECTION 00300 BID PROPOSAL FORM
- SECTION 00350 NON-COLLUSION AFFIDAVIT
- SECTION 00400 STATEMENT OF BIDDER’S QUALIFICATIONS
- SECTION 00450 CERTIFICATION OF SITE VISIT
- SECTION 00500 PAYMENT AND PERFORMANCE BOND
- SECTION 00510 NOTICE OF AWARD
- SECTION 00600 CONSTRUCTION AGREEMENT
- SECTION 00650 NOTICE TO PROCEED
- SECTION 00700 GENERAL CONDITIONS

### DIVISION 01 - GENERAL REQUIREMENTS
- SECTION 01010 SUMMARY OF WORK
- SECTION 01015 ADDITIONAL REQUIREMENTS FOR DSA-APPROVED PROJECTS
- SECTION 01030 ALTERNATES
- SECTION 01050 FIELD ENGINEERING
- SECTION 01055 CONFORMANCE SURVEYING
- SECTION 01140 WORK RESTRICTIONS
- SECTION 01250 CONTRACT MODIFICATION PROCEDURES
- SECTION 01290 PAYMENT PROCEDURES
- SECTION 01300 LABOR COMPLIANCE PROGRAM
- SECTION 01305 DELAY AND EXTENSIONS TO THE WORK
- SECTION 01310 CONSTRUCTION SCHEDULING
- SECTION 01311 PROJECT MANAGEMENT AND COORDINATION
- SECTION 01312 PROJECT MEETINGS
- SECTION 01316 BUILDING INFORMATION MODELING (BIM)
- SECTION 01318 DOCUMENT MANAGEMENT SYSTEM
- SECTION 01321 PHOTOGRAPHIC DOCUMENTATION
- SECTION 01330 SUBMITTAL PROCEDURES
- SECTION 01340 ADMINISTRATIVE FORMS AND LOGS
- SECTION 01400 QUALITY CONTROL REQUIREMENTS
- SECTION 01405 MOCKUP REQUIREMENTS, Provided by SmithGroup
- SECTION 01410 REGULATORY REQUIREMENTS
- SECTION 01411 TESTING LABORATORY SERVICES
- SECTION 01412 HAZARDOUS MATERIALS
- SECTION 01414 GUIDELINES FOR OPERATIONS DURING A PROTEST
- SECTION 01415 MITIGATION MONITORING REGULATORY REQUIREMENTS
- SECTION 01416 SPECIAL PROCEDURES
- SECTION 01420 REFERENCES
- SECTION 01500 TEMPORARY FACILITIES AND CONTROL
- SECTION 01505 CONSTRUCTION WASTE MANAGEMENT
- SECTION 01540 SITE SECURITY AND SAFETY
SECTION 01572 STORM WATER POLLUTION PREVENTION
SECTION 01610 BASIC PRODUCT REQUIREMENTS
SECTION 01625 PRODUCT OPTIONS AND SUBSTITUTIONS
SECTION 01710 CLEANING REQUIREMENTS
SECTION 01722 EXECUTION REQUIREMENTS
SECTION 01730 CUTTING AND PATCHING
SECTION 01740 WARRANTIES / GUARANTEES
SECTION 01770 CONTRACT CLOSEOUT PROCEDURES
SECTION 01780 PROJECT RECORD DOCUMENTS
SECTION 01785 OPERATIONS AND MAINTENANCE DATA
SECTION 01805 CALGREEN ENVIRONMENTAL REQUIREMENTS, Provided by SmithGroup
SECTION 01813 SUSTAINABLE DESIGN REQUIREMENTS, Provided by SmithGroup
SECTION 01820 DEMONSTRATION AND TRAINING
SECTION 01913 GENERAL COMMISSIONING REQUIREMENTS, Provided by Enovity

VOLUME 2 – TECHNICAL SPECIFICATIONS - DIVISION 02 - 14, Provided by SmithGroup

DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS
SECTION 00001 TITLE PAGE
SECTION 00007 SEALS PAGE
SECTION 00010 TABLE OF CONTENTS

DIVISION 02 - EXISTING CONDITIONS
SECTION 024113 SELECTIVE SITE DEMOLITION

DIVISION 03 - CONCRETE
SECTION 030413 COMMON SUBMITTAL REQUIREMENTS FOR CONCRETE
SECTION 031100 CONCRETE FORMING
SECTION 031500 CONCRETE ACCESSORIES
SECTION 032000 CONCRETE REINFORCING
SECTION 033000 CAST-IN-PLACE CONCRETE
SECTION 033543 POLISHED CONCRETE FINISHING
SECTION 033546 SEALED CONCRETE FINISHING
SECTION 036100 GROUTED DOWELS IN CONCRETE

DIVISION 04 - MASONRY
SECTION 040413 COMMON SUBMITTAL REQUIREMENTS FOR MASONRY
SECTION 042113 BRICK MASONRY

DIVISION 05 - METALS
SECTION 050413 COMMON SUBMITTAL REQUIREMENTS FOR METALS
SECTION 050525 POST-INSTALLED CONCRETE ANCHORS
SECTION 051200 STRUCTURAL STEEL FRAMING
SECTION 051213 ARCHITECTURALLY EXPOSED STRUCTURAL STEEL (AESS)
SECTION 051250 BUCKLING RESTRAINED BRACES
SECTION 053100 STEEL DECKING
SECTION 054000 COLD-FORMED METAL FRAMING
SECTION 055000 METAL FABRICATIONS
SECTION 055113 METAL PAN STAIRS
SECTION 055119 METAL GRATING STAIRS
SECTION 055213 PIPE AND TUBE RAILINGS
SECTION 057005 LANDSCAPE METALWORK
SECTION 057100 DECORATIVE METAL STAIRS
SECTION 057300 DECORATIVE METAL RAILINGS
## DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES

- **SECTION 060413** COMMON SUBMITTAL REQUIREMENTS FOR WOODS, PLASTICS, AND COMPOSITES
- **SECTION 061000** ROUGH CARPENTRY
- **SECTION 061600** SHEATHING
- **SECTION 064116** PLASTIC-LAMINATE-FACED ARCHITECTURAL CABINETS
- **SECTION 066400** PLASTIC PANELING

## DIVISION 07 - THERMAL AND MOISTURE PROTECTION

- **SECTION 070413** COMMON SUBMITTAL REQUIREMENTS FOR THERMAL AND MOISTURE PROTECTION
- **SECTION 071113** BITUMINOUS DAMPPROOFING
- **SECTION 071326** BELOW-GRADE SHEET WATERPROOFING
- **SECTION 071413** HOT FLUID-APPLIED RUBBERIZED ASPHALT WATERPROOFING
- **SECTION 071619** METAL OXIDE WATERPROOFING
- **SECTION 072100** THERMAL INSULATION
- **SECTION 072726** MEMBRANE AIR BARRIERS
- **SECTION 074213** METAL WALL PANELS
- **SECTION 075419** POLYVINYL-CHLORIDE (PVC) ROOFING
- **SECTION 075556** FLUID-APPLIED PROTECTED MEMBRANE ROOFING
- **SECTION 076200** SHEET METAL FLASHING AND TRIM
- **SECTION 077200** ROOF ACCESSORIES
- **SECTION 078413** PENETRATION FIRESTOPPING
- **SECTION 078443** JOINT FIRESTOPPING AND FIRESAFING
- **SECTION 079200** JOINT SEALANTS
- **SECTION 079513.16** EXTERIOR EXPANSION JOINT COVER ASSEMBLIES

## DIVISION 08 - OPENINGS

- **SECTION 080413** COMMON SUBMITTAL REQUIREMENTS FOR OPENINGS
- **SECTION 081113** HOLLOW METAL DOORS AND FRAMES
- **SECTION 081416** FLUSH WOOD DOORS
- **SECTION 083113** ACCESS DOORS AND FRAMES
- **SECTION 083473.13** METAL SOUND CONTROL DOOR ASSEMBLIES
- **SECTION 084113** ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS
- **SECTION 084216** INTERIOR ALUMINUM STOREFRONT FRAMES
- **SECTION 084229.23** SLIDING AUTOMATIC ENTRANCES
- **SECTION 084413** GLAZED ALUMINUM CURTAIN WALLS
- **SECTION 084423** STRUCTURAL-SEALANT-GLAZED CURTAIN WALLS
- **SECTION 085113** MISCELLANEOUS INTERIOR ALUMINUM WINDOWS
- **SECTION 087100** DOOR HARDWARE
- **SECTION 087113** AUTOMATIC DOOR OPERATORS
- **SECTION 088000** GLAZING
- **SECTION 088300** MIRRORS
- **SECTION 088813** FIRE-RESISTANT GLAZING AND FRAMING
- **SECTION 089119** FIXED LOUVERS

## DIVISION 09 - FINISHES

- **SECTION 090413** COMMON SUBMITTAL REQUIREMENTS FOR FINISHES
- **SECTION 090561.13** MOISTURE VAPOR EMISSION CONTROL
- **SECTION 092116.23** GYPSUM BOARD SHAFT WALL ASSEMBLIES
- **SECTION 092216** NON-STRUCTURAL METAL FRAMING
- **SECTION 092400** CEMENT PLASTERING
- **SECTION 092900** GYPSUM BOARD
- **SECTION 093013** TILING
- **SECTION 095113** SUSPENDED ACOUSTICAL CEILINGS
DIVISION 09 - CONSTRUCTION PRODUCTS

SECTION 095423  SUSPENDED METAL CEILINGS
SECTION 096513  RESILIENT BASE AND ACCESSORIES
SECTION 096516  RESILIENT SHEET FLOORING
SECTION 096519  RESILIENT TILE FLOORING
SECTION 096723  RESINOUS FLOORING AND WALL COATINGS
SECTION 096813  TILE CARPETING
SECTION 097200  WALL COVERINGS
SECTION 098100  ACOUSTICAL INSULATION
SECTION 098433  SOUND-ABSORBING WALL AND CEILING UNITS
SECTION 099113  EXTERIOR PAINTING
SECTION 099123  INTERIOR PAINTING
SECTION 099600  HIGH-PERFORMANCE COATINGS

DIVISION 10 - SPECIALTIES

SECTION 100413  COMMON SUBMITTAL REQUIREMENTS FOR SPECIALTIES
SECTION 101100  VISUAL DISPLAY UNITS
SECTION 101200  DISPLAY CASES
SECTION 101419  DIMENSIONAL LETTER SIGNAGE
SECTION 101423  SIGNAGE
SECTION 102113.17  PHENOLIC-CORE TOILET COMPARTMENTS
SECTION 102600  WALL AND DOOR PROTECTION
SECTION 102800  TOILET, BATH AND MISCELLANEOUS ACCESSORIES
SECTION 104413  FIRE PROTECTION CABINETS
SECTION 104416  FIRE EXTINGUISHERS

DIVISION 11 - EQUIPMENT

SECTION 110413  COMMON SUBMITTAL REQUIREMENTS FOR EQUIPMENT
SECTION 113100  RESIDENTIAL APPLIANCES
SECTION 115310  LABORATORY CASEWORK AND OTHER FURNISHINGS
SECTION 115313  FUME HOODS AND OTHER AIR CONTAINMENT UNITS
SECTION 115343  LABORATORY SERVICE FITTINGS AND FIXTURES
SECTION 115350  LABORATORY EQUIPMENT

DIVISION 12 - FURNISHINGS

SECTION 120413  COMMON SUBMITTAL REQUIREMENTS FOR FURNISHINGS
SECTION 122413  ROLLER WINDOW SHADES
SECTION 123661.16  SOLID SURFACING COUNTERTOPS
SECTION 124813  ENTRANCE FLOOR MATS
SECTION 126100  FIXED AUDIENCE SEATING

DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 130413  COMMON SUBMITTAL REQUIREMENTS FOR SPECIAL CONSTRUCTION
SECTION 132300  PLANETARIUM DOME
SECTION 132310  PLANETARIUM PROJECTION SYSTEM

DIVISION 14 - CONVEYING EQUIPMENT

SECTION 140413  COMMON SUBMITTAL REQUIREMENTS FOR CONVEYING EQUIPMENT
SECTION 142123.16  MACHINE-ROOM-LESS ELECTRIC TRACTION ELEVATORS

VOLUME 3 – TECHNICAL SPECIFICATIONS - DIVISION 21 – 33, Provided by SmithGroup

DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS

SECTION 00001  TITLE PAGE
SECTION 00007  SEALS PAGE
## SECTION 00010 TABLE OF CONTENTS

### DIVISION 21 - FIRE SUPPRESSION
- SECTION 210413 COMMON SUBMITTAL REQUIREMENTS FOR FIRE SUPPRESSION
- SECTION 211313 WET-PIPE SPRINKLER SYSTEM

### DIVISION 22 - PLUMBING
- SECTION 220000 PLUMBING GENERAL REQUIREMENTS
- SECTION 220413 COMMON SUBMITTAL REQUIREMENTS FOR PLUMBING
- SECTION 220513 COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT
- SECTION 220517 SLEEVES AND SLEEVE SEALS FOR PLUMBING
- SECTION 220518 ESCUTCHEONS FOR PLUMBING PIPING
- SECTION 220519 METERS AND GAUGES FOR PLUMBING PIPING
- SECTION 220523 GENERAL DUTY VALVES FOR PLUMBING PIPING
- SECTION 220529 HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
- SECTION 220548 VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT
- SECTION 220553 IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
- SECTION 220716 PLUMBING EQUIPMENT INSULATION
- SECTION 220719 PLUMBING PIPING INSULATION
- SECTION 220800 COMMISSIONING OF PLUMBING SYSTEMS
- SECTION 221116 DOMESTIC WATER PIPING
- SECTION 221118 NATURAL-GAS PIPING
- SECTION 221119 DOMESTIC WATER PIPING SPECIALTIES
- SECTION 221123.13 DOMESTIC-WATER PACKAGED BOOSTER PUMPS
- SECTION 221316 SANITARY WASTE AND VENT PIPING
- SECTION 221319 SANITARY WASTE PIPING SPECIALTIES
- SECTION 221319.13 SANITARY DRAINS
- SECTION 221413 STORM DRAINAGE PIPING
- SECTION 221423 STORM DRAINAGE PIPING SPECIALTIES
- SECTION 223000 PLUMBING EQUIPMENT
- SECTION 223600 REVERSE OSMOSIS WATER EQUIPMENT
- SECTION 224200 PLUMBING FIXTURES
- SECTION 224500 EMERGENCY PLUMBING FIXTURES
- SECTION 225213 VACUUM PIPING FOR LABORATORY FACILITIES
- SECTION 226219 VACUUM EQUIPMENT FOR LABORATORY FACILITIES
- SECTION 226600 LABORATORY WASTE SYSTEMS FOR LABORATORY FACILITIES
- SECTION 226700 PROCESSED WATER SYSTEMS FOR LABORATORY FACILITIES

### DIVISION 23 - HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)
- SECTION 230000 HVAC GENERAL REQUIREMENTS
- SECTION 230413 COMMON SUBMITTAL REQUIREMENTS FOR HVAC
- SECTION 230513 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
- SECTION 230514 VARIABLE-FREQUENCY DRIVES FOR HVAC EQUIPMENT
- SECTION 230516 EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING
- SECTION 230519 METERS AND GAUGES FOR HVAC PIPING
- SECTION 230523 VALVES FOR HVAC PIPING
- SECTION 230529 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
- SECTION 230548 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
- SECTION 230553 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
- SECTION 230593 TESTING, ADJUSTING, AND BALANCING FOR HVAC
- SECTION 230713 HVAC DUCT INSULATION
- SECTION 230716 HVAC PIPING AND EQUIPMENT INSULATION
- SECTION 230800 COMMISSIONING OF MECHANICAL SYSTEMS
- SECTION 232113 HYDRONIC PIPING
SECTION 232116 HYDRONIC PIPING SPECIALTIES
SECTION 232123 HYDRONIC PUMPS
SECTION 232500 HVAC WATER TREATMENT
SECTION 233100 HVAC METAL DUCTS
SECTION 233300 HVAC DUCT ACCESSORIES
SECTION 233400 HVAC FANS
SECTION 233600 AIR TERMINAL UNITS
SECTION 233700 AIR OUTLETS AND INLETS
SECTION 237300 CUSTOM AIR HANDLING UNITS
SECTION 238143 AIR-SOURCE UNITARY HEAT PUMPS
SECTION 238219 FAN COIL UNITS

DIVISION 25 - INTEGRATED AUTOMATION
SECTION 250000 BUILDING AUTOMATION SYSTEMS
SECTION 250413 COMMON SUBMITTAL REQUIREMENTS FOR INTEGRATED AUTOMATION
SECTION 253000 BUILDING AUTOMATION SENSORS AND CONTROL DEVICES
SECTION 255000 BUILDING AUTOMATION HARDWARE AND NETWORKING
SECTION 255005 LABORATORY MONITORING AND CONTROL SYSTEM
SECTION 259000 BUILDING AUTOMATION SEQUENCES OF OPERATIONS

DIVISION 26 - ELECTRICAL
SECTION 260413 COMMON SUBMITTAL REQUIREMENTS FOR ELECTRICAL
SECTION 260513 MEDIUM-VOLTAGE CABLES
SECTION 260519 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
SECTION 260526 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
SECTION 260529 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
SECTION 260533 RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
SECTION 260543 UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS
SECTION 260544 SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLES
SECTION 260548.16 SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS
SECTION 260553 IDENTIFICATION FOR ELECTRICAL SYSTEMS
SECTION 260572 OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY
SECTION 260573 OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY
SECTION 260574 OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY
SECTION 260800 COMMISSIONING OF ELECTRICAL SYSTEMS
SECTION 260913.01 ELECTRICAL POWER MONITORING AND CONTROL
SECTION 260923.02 LIGHTING CONTROLS
SECTION 261219 PAD MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS
SECTION 262213 LOW-VOLTAGE DISTRIBUTION TRANSFORMERS
SECTION 262413 SWITCHBOARDS
SECTION 262416 PANELBOARDS
SECTION 262726 WIRING DEVICES
SECTION 262813 FUSES
SECTION 262816 ENCLOSED SWITCHES AND CIRCUIT BREAKERS
SECTION 263213.13 DIESEL EMERGENCY ENGINE GENERATORS
SECTION 263600 TRANSFER SWITCHES
SECTION 264313 SURGE PROTECTION FOR LOW VOLTAGE ELECTRICAL POWER CIRCUITS
SECTION 265119 LED INTERIOR LIGHTING
SECTION 265613 LIGHTING POLES AND STANDARDS
SECTION 265619 LED EXTERIOR LIGHTING
SECTION 266315 PLANETARIUM LIGHTING TECHNOLOGY PACKAGE (PLTS)
DIVISION 27 - COMMUNICATIONS
SECTION 270000 BASIC COMMUNICATIONS REQUIREMENTS
SECTION 270413 COMMON SUBMITTAL REQUIREMENTS FOR COMMUNICATIONS
SECTION 270526 COMMUNICATIONS GROUNDING AND BONDING
SECTION 270528 COMMUNICATIONS BUILDING PATHWAYS
SECTION 270533 COMMUNICATIONS BUILDING PATHWAYS – CONDUITS AND BOXES
SECTION 270536 COMMUNICATIONS BUILDING PATHWAYS – CABLE TRAYS
SECTION 270811 COMMUNICATIONS TWISTED PAIR TESTING
SECTION 270821 COMMUNICATIONS FIBER OPTIC TESTING
SECTION 271100 COMMUNICATIONS EQUIPMENT ROOMS
SECTION 271313 COMMUNICATIONS BACKBONE ISP TWISTED PAIR CABLING
SECTION 271314 COMMUNICATIONS BACKBONE OSP TWISTED PAIR CABLING
SECTION 271323 COMMUNICATIONS BACKBONE ISP FIBER OPTIC CABLING
SECTION 271324 COMMUNICATIONS BACKBONE OSP FIBER OPTIC CABLING
SECTION 271513 COMMUNICATIONS HORIZONTAL TWISTED PAIR CABLING
SECTION 272310 INSTRUCTIONAL PLANETARIUM MEDIA SYSTEMS (IPMS)
SECTION 272315 PLANETARIUM SOUND SYSTEM (PSS)
SECTION 274113 ARCHITECTURALLY INTEGRATED PROJECTION SCREENS
SECTION 274116 INTEGRATED AUDIOVISUAL SYSTEMS

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY
SECTION 280000 BASIC SECURITY REQUIREMENTS
SECTION 280413 COMMON SUBMITTAL REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY
SECTION 280513 SECURITY SYSTEM CABLING
SECTION 280553 SECURITY SYSTEM LABELING
SECTION 280800 SECURITY SYSTEM ACCEPTANCE TESTING
SECTION 281300 ACCESS CONTROL AND ALARM MONITORING SYSTEM
SECTION 281600 INTRUSION DETECTION SYSTEM
SECTION 282300 VIDEO SURVEILLANCE SYSTEM
SECTION 283100 ANALOG ADDRESSABLE FIRE ALARM DETECTION SYSTEM

DIVISION 31 - EARTHWORK
SECTION 310413 COMMON SUBMITTAL REQUIREMENTS FOR EARTHWORK
SECTION 311001 PLANT PROTECTION
SECTION 311100 CLEARING & GRUBBING
SECTION 311200 SOIL STRIPPING & STOCKPILING
SECTION 312300 EXCAVATION AND FILL
SECTION 312305 STRUCTURAL EXCAVATION AND FILL
SECTION 312333 UTILITY TRENCHING AND BACKFILLING
SECTION 312500 EROSION AND SEDIMENTATION CONTROL
SECTION 315000 TEMPORARY EXCAVATION SUPPORT AND PROTECTION
SECTION 316800 FOUNDATION TIEDOWN ANCHORS

DIVISION 32 - EXTERIOR IMPROVEMENTS
SECTION 320413 COMMON SUBMITTAL REQUIREMENTS FOR EXTERIOR IMPROVEMENTS
SECTION 320523 PORTLAND CEMENT CONCRETE PAVING
SECTION 320800 COMMISSIONING OF IRRIGATION SYSTEMS
SECTION 321132 AGGREGATE BASE COURSE
SECTION 321312 SITE CONCRETE
SECTION 321616 ASPHALT CONCRETE PAVEMENT
SECTION 323300 SITE FURNISHINGS
SECTION 328400 IRRIGATION
SECTION 329000 PLANTING
SECTION 329451 MODULAR SUSPENDED PAVEMENT SYSTEM
SECTION 329456   PLANTING SOIL FOR MODULAR SUSPENDED SYSTEM

DIVISION 33 - UTILITIES
SECTION 330413   COMMON SUBMITTAL REQUIREMENTS FOR UTILITIES
SECTION 331166   WATER DISTRIBUTION SYSTEM
SECTION 334100   STORM DRAINAGE SYSTEM

DRAWINGS – Provided by SmithGroup

GENERAL
G0.0       PROJECT COVER SHEET
G0.1       PROJECT SHEET INDEX
G0.2       GENERAL PROJECT INFORMATION
G0.3       BASIC ACCESSIBILITY REQUIREMENTS
G0.4       BASIC ACCESSIBILITY REQUIREMENTS
G0.5       TYPICAL TOILET ROOM MOUNTING HEIGHTS AND STALL CONFIGURATION DIAGRAMS
G0.6       TYPICAL MOUNTING HEIGHTS AND DIMENSIONING CONVENTIONS
G0.7       TYPICAL RULES FOR DETERMINING MOUNTING HEIGHTS AND LOCATIONS
G0.8       TYPICAL REFLECTED CEILING ITEMS LOCATIONS AND CONFIGURATIONS AND SPRINKLER HEAD TOLERANCES
G0.9       HAZARDOUS MATERIAL INVENTORY STATEMENT
G0.10      HAZARDOUS MATERIAL INVENTORY STATEMENT
G0.11      HAZARDOUS MATERIAL INVENTORY STATEMENT
G1.1       ACCESSIBILITY SITE PLAN
G2.2.1     FIRE AND LIFE SAFETY DRAWINGS LEVEL 1
G2.2.2     FIRE AND LIFE SAFETY DRAWINGS LEVEL 2
G2.2.3     FIRE AND LIFE SAFETY DRAWINGS LEVEL 3
G2.2.4     FIRE AND LIFE SAFETY DRAWINGS ROOF

CIVIL
C1.00.V2   EXISTING SITE PLAN
C1.01.V2   EXISTING UTILITY PLAN
C2.00.V2   DEMOLITION PLAN
C3.00.V2   HORIZONTAL CONTROL PLAN
C4.00.V2   GRADING PLAN
C5.00.V2   UTILITY PLAN
C6.00.V2   EROSION CONTROL PLAN
C7.00.V2   CONSTRUCTION DETAILS
C8.00.V2   FIRE ACCESS PLAN

LANDSCAPE
L0.00      COVER SHEET
L1.00      LAYOUT PLAN
L1.01      CONSTRUCTION PLAN
L2.00      CONSTRUCTION DETAILS
L2.01      CONSTRUCTION DETAILS
L2.02      CONSTRUCTION DETAILS
L3.00      SOIL PLACEMENT PLAN
L4.00      IRRIGATION NOTES & LEGEND
L4.01      IRRIGATION PLAN
L4.02      IRRIGATION DETAILS
L4.03 IRRIGATION DETAILS
L5.00 PLANTING SCHEDULE
L5.01 TREE PLAN
L5.02 PLANTING PLAN
L5.03 PLANTING DETAILS

STRUCTURAL

S0.01 GENERAL NOTES
S0.02 GENERAL NOTES
S0.03 COLD-FORMED STEEL FRAMING GENERAL NOTES
S0.04 ISOMETRIC VIEWS
S0.05 ISOMETRIC OF PLANETARIUM FRAMING
S0.06 DESIGN LIVE LOAD & VIBRATION CRITERIA KEY PLANS
S0.07 SEISMIC LOAD RESISTING SYSTEM DIAGRAM
S2.01 FOUNDATION PLAN AND LEVEL 1
S2.02 LEVEL 2 FRAMING PLAN
S2.03 LEVEL 3 FRAMING PLAN
S2.04 ROOF FRAMING PLAN
S2.05 SKY OBSERVATION EXTERIOR CLADDING SUPPORT PLAN
S2.06 PLAZA WALL ELEVATIONS AND DETAILS
S3.01 TYPICAL CONCRETE DETAILS
S3.02 TYPICAL CONCRETE DETAILS
S3.03 TYPICAL FOUNDATION DETAILS
S3.04 SLAB ON GRADE & RETAINING WALL DETAILS
S3.05 TYPICAL FOOTING AND THICKENED SLAB DETAILS
S3.06 TYPICAL CONCRETE GRADE BEAM DETAILS
S3.07 FOUNDATION DETAILS
S3.08 FOOTING ELEVATIONS
S4.01 BRACE FRAME ELEVATIONS
S4.02 BRACE FRAME ELEVATIONS
S4.03 BRACE FRAME ELEVATIONS
S4.04 PLANETARIUM EXTERIOR FRAME ELEVATION
S4.05 BUILDING SECTION AT PLANETARIUM
S4.06 BUILDING SECTION AT PLANETARIUM
S4.10 EXTERIOR WALL FRAME ELEVATIONS
S4.11 EXTERIOR WALL FRAME ELEVATIONS
S4.12 EXTERIOR WALL SECTIONS
S4.13 EXTERIOR WALL SECTIONS
S4.14 EXTERIOR WALL SECTIONS
S4.15 EXTERIOR WALL SECTIONS
S5.01 STEEL NON-FRAME COLUMN SCHEDULE AND DETAILS
S5.02 COLUMN SCHEDULE AND STEEL COLUMN DETAILS
S5.03 TYPICAL STEEL DETAILS
S5.04 TYPICAL STEEL DETAILS
S5.05 TYPICAL STEEL DETAILS
S5.06 STEEL DETAILS
S5.07 ROOF STEEL DETAILS
S5.08 SKY ROOF STEEL DETAILS
S5.09 SKY ROOF STEEL DETAILS
S5.10 ANCHORAGE DETAILS
S5.11 EXTERIOR CLADDING SUPPORT DETAILS
S5.12 EXTERIOR CLADDING SUPPORT DETAILS
S5.13 EXTERIOR CLADDING SUPPORT DETAILS
S5.21 TYPICAL STEEL DECK DETAILS
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S5.22</td>
<td>TYPICAL STEEL DECK DETAILS</td>
</tr>
<tr>
<td>S5.23</td>
<td>TYPICAL STEEL DECK DETAILS</td>
</tr>
<tr>
<td>S5.24</td>
<td>TYPICAL STEEL DECK DETAILS</td>
</tr>
<tr>
<td>S5.25</td>
<td>TYPICAL STEEL DECK DETAILS</td>
</tr>
<tr>
<td>S5.26</td>
<td>HOOD DETAILS AND HANGER ATTACHMENT DETAILS</td>
</tr>
<tr>
<td>S5.30</td>
<td>BRB GENERAL NOTES</td>
</tr>
<tr>
<td>S5.31</td>
<td>BRACED FRAME DETAILS</td>
</tr>
<tr>
<td>S5.32</td>
<td>BRACED FRAME DETAILS</td>
</tr>
<tr>
<td>S5.33</td>
<td>BRACED FRAME DETAILS</td>
</tr>
<tr>
<td>S5.34</td>
<td>BRACED FRAME DETAILS</td>
</tr>
<tr>
<td>S5.35</td>
<td>LATERAL FRAMING DETAILS</td>
</tr>
<tr>
<td>S5.40</td>
<td>COREBRACE BRB DETAILS</td>
</tr>
<tr>
<td>S5.41</td>
<td>COREBRACE BRB SCHEDULES</td>
</tr>
<tr>
<td>S5.42</td>
<td>COREBRACE BRB ERECTION DETAILS</td>
</tr>
<tr>
<td>S5.43</td>
<td>COREBRACE BRB ERECTION DETAILS</td>
</tr>
<tr>
<td>S5.50</td>
<td>PLANETARIUM ENCLOSURE FRAME DETAILS</td>
</tr>
<tr>
<td>S5.51</td>
<td>DETAILS</td>
</tr>
<tr>
<td>S5.60</td>
<td>TYPICAL STAIR DETAILS</td>
</tr>
<tr>
<td>S5.61</td>
<td>TYPICAL STAIR DETAILS</td>
</tr>
<tr>
<td>S5.70</td>
<td>TYPICAL MECHANICAL DUCT SUPPORT DETAILS</td>
</tr>
<tr>
<td>S5.71</td>
<td>ROOF SCREEN DETAILS</td>
</tr>
<tr>
<td>S5.90</td>
<td>EXHAUST STACK SUPPORT DETAILS</td>
</tr>
<tr>
<td>S7.01</td>
<td>STAIR #1 &amp; ELEVATOR PARTIAL PLANS</td>
</tr>
<tr>
<td>S7.02</td>
<td>STAIR #2 PLANS</td>
</tr>
<tr>
<td>S7.03</td>
<td>STAIR #3 PLANS AND SECTIONS</td>
</tr>
<tr>
<td>S7.10</td>
<td>ELEVATOR GUIDE RAIL SUPPORT ELEVATIONS AND DETAILS</td>
</tr>
<tr>
<td>S9.00</td>
<td>INTERIOR PARTITION WALL GENERAL NOTES &amp; TYPICAL DETAILS</td>
</tr>
<tr>
<td>S9.01</td>
<td>INTERIOR PARTITION SCHEDULE &amp; DETAILS</td>
</tr>
<tr>
<td>S9.02</td>
<td>INTERIOR PARTITION DETAILS</td>
</tr>
<tr>
<td>S9.03</td>
<td>INTERIOR PARTITIONS TYPICAL ANCHORAGE - BACKING PLATES</td>
</tr>
<tr>
<td>S9.04</td>
<td>INTERIOR PARTITION &amp; MISC. DETAILS</td>
</tr>
<tr>
<td>S9.06</td>
<td>CORRIDOR MEP &amp; CEILING SUPPORT DETAILS</td>
</tr>
<tr>
<td>S9.11</td>
<td>EXTERIOR METAL STUD FRAMING TYP DTLS</td>
</tr>
<tr>
<td>S9.12</td>
<td>EXTERIOR METAL STUD FRAMING TYP DTLS</td>
</tr>
<tr>
<td>S9.13</td>
<td>EXTERIOR METAL STUD FRAMING TYP DTLS</td>
</tr>
<tr>
<td>S9.20</td>
<td>TYPICAL CFS SHEARWALL DETAILS</td>
</tr>
<tr>
<td>SA.01</td>
<td>MEP EQUIPMENT ANCHORAGE</td>
</tr>
<tr>
<td>SA.02</td>
<td>MEP EQUIPMENT ANCHORAGE</td>
</tr>
</tbody>
</table>

**ARCHITECTURAL EDGE OF SLAB**

| AS2.1.1 | LEVEL 1 SLAB EDGE PLAN |
| AS2.1.2 | LEVEL 2 SLAB EDGE PLAN |
| AS2.1.3 | LEVEL 3 SLAB EDGE PLAN |
| AS2.1.4 | ROOF SLAB EDGE PLAN |

**ARCHITECTURAL**

| A0.1     | ARCHITECTURAL ABBREVIATIONS AND SYMBOLS |
| A1.1.1   | LEVEL 1 ARCHITECTURAL SITE PLAN |
| A1.2.1   | LEVEL 2 ARCHITECTURAL SITE PLAN |
| A1.3.1   | ARCHITECTURAL SITE DETAILS |
| A2.1.1   | LEVEL 1 FLOOR PLAN |
| A2.1.2   | LEVEL 1 PARTITION AND DIMENSION PLAN |
| A2.1.3   | LEVEL 1 FINISH FLOOR PLAN |
| A2.2.1   | LEVEL 2 FLOOR PLAN |
| A2.2.2   | LEVEL 2 PARTITION AND DIMENSION PLAN |
A6.5.1 TYPICAL STAIR DETAILS
A6.5.2 TYPICAL STAIR DETAILS
A6.5.3 ROOF STAIR DETAILS
A6.6.1 ELEVATOR PLANS AND SECTIONS
A6.6.2 ELEVATOR DETAILS
A6.6.3 ELEVATOR CAB DETAILS
A7.1.1 ENLARGED RESTROOM FLOOR PLANS
A7.2.1 LEVEL 2 - ENLARGED LOBBY & TUTORING CENTER FLOOR PLAN
A7.2.2 LEVEL 2 - ENLARGED LOBBY & TUTORING CENTER ELEVATIONS & AXONOMETRIC
A7.3.1 LEVEL 3 - ENLARGED LOBBY & PLANETARIUM FLOOR PLAN
A7.3.2 LEVEL 3 - ENLARGED PLANETARIUM ELEVATIONS & AXONOMETRIC
A7.4.1 ENLARGED PLANETARIUM SHELL FLOOR PLANS
A7.4.2 ENLARGED PLANETARIUM SHELL ELEVATIONS AND AXONOMETRIC
A7.4.3 STR COORDINATION PLANETARIUM PLAN
A8.0.1 INTERIOR PERSPECTIVES
A8.0.2 INTERIOR PERSPECTIVES
A8.1.1 INTERIOR ELEVATIONS
A8.1.2 INTERIOR ELEVATIONS
A8.1.3 INTERIOR ELEVATIONS
A8.1.4 INTERIOR ELEVATIONS
A8.1.5 INTERIOR ELEVATIONS
A8.1.6 INTERIOR ELEVATIONS
A8.1.7 INTERIOR ELEVATIONS
A8.1.8 INTERIOR ELEVATIONS
A8.1.9 INTERIOR ELEVATIONS
A8.1.10 INTERIOR ELEVATIONS
A8.1.11 INTERIOR ELEVATIONS
A8.2.1 CORRIDOR COORDINATION SECTIONS
A8.2.2 MECHANICAL SHAFT COORDINATION
A9.1.1A APPLIED FINISHES SCHEDULE
A9.1.1B APPLIED FINISHES SCHEDULE
A9.1.2 FINISH DETAILS
A9.2.1 INTERIOR PARTITION SYSTEMS
A9.2.2 INTERIOR PARTITION SCHEDULE AND ADDITIONAL COMPONENTS MATRIX
A9.2.3 TYPICAL INTERIOR FRAMING DETAILS
A9.2.4 TYPICAL INTERIOR METAL FRAMED PARTITION DETAILS AND BACKING PLATE SCHEDULE
A9.2.5 TYPICAL INTERIOR FRAMED PARTITION DETAILS
A9.2.6 TYPICAL INTERIOR PARTITION PENETRATION DETAILS
A9.2.7 INTERIOR PARTITION DETAILS
A9.2.8 INTERIOR PARTITION DETAILS
A9.2.10 UL ASSEMBLY DETAILS
A9.2.11 UL ASSEMBLY DETAILS
A9.2.12 UL ASSEMBLY DETAILS
A9.2.13 UL ASSEMBLY DETAILS
A9.2.14 UL ASSEMBLY DETAILS
A9.2.15 UL ASSEMBLY DETAILS
A9.3.1 DOOR SCHEDULE
A9.3.2 DOOR AND FRAME ELEVATIONS
A9.3.3 TYPICAL DOOR DETAILS
A9.3.4 INTERIOR DOOR DETAILS
A9.3.5 INTERIOR DOOR DETAILS
A9.4.1 TYPICAL CEILING DETAILS
A9.4.2 TYPICAL CEILING DETAILS
A9.4.3 CEILING DETAILS
A9.4.4 CEILING DETAILS
### DSA Appl. #01-117149

Contra Costa Community College District
Contra Costa College
C-4016 New Science Building – Increment 2

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A9.4.5</td>
<td>ENLARGED TUTORIAL AREA RCP</td>
</tr>
<tr>
<td>A9.4.6</td>
<td>ENLARGED LEVEL 2 FACULTY CORRIDOR RCP</td>
</tr>
<tr>
<td>A9.4.7</td>
<td>LEVEL 3 - ENLARGED LOBBY &amp; PLANETARIUM REFLECTED CEILING PLAN</td>
</tr>
<tr>
<td>A9.4.8</td>
<td>LEVEL 3 - ENLARGED LOBBY &amp; PLANETARIUM CEILING DETAILS</td>
</tr>
<tr>
<td>A9.4.10</td>
<td>DSA IR 25-2.13 CEILING DETAILS AND NOTES PART 1</td>
</tr>
<tr>
<td>A9.4.11</td>
<td>DSA IR 25-2.13 CEILING DETAILS AND NOTES PART 2</td>
</tr>
<tr>
<td>A9.4.12</td>
<td>DSA IR 25-2.13 CEILING DETAILS AND NOTES PART 3 &amp; DSA IR 25-3.13 GYP. BD. CEILING NOTES</td>
</tr>
<tr>
<td>A9.4.13</td>
<td>ICC ESR REPORTS FOR REFERENCE ONLY</td>
</tr>
<tr>
<td>A9.4.14</td>
<td>ICC ESR REPORTS FOR REFERENCE ONLY</td>
</tr>
<tr>
<td>A9.5.1</td>
<td>INTERIOR CONSTRUCTION DETAILS</td>
</tr>
<tr>
<td>A9.5.2</td>
<td>INTERIOR CONSTRUCTION DETAILS</td>
</tr>
<tr>
<td>A9.6.1</td>
<td>MODULAR CASEWORK SCHEDULE AND DETAILS</td>
</tr>
<tr>
<td>A9.6.2</td>
<td>MODULAR CASEWORK DETAILS</td>
</tr>
<tr>
<td>A9.6.3</td>
<td>CASEWORK DETAILS</td>
</tr>
<tr>
<td>A9.6.4</td>
<td>CASEWORK DETAILS</td>
</tr>
<tr>
<td>A9.7.1</td>
<td>CUSTOM ARCHITECTURAL CASEWORK</td>
</tr>
<tr>
<td>A9.7.2</td>
<td>CUSTOM ARCHITECTURAL CASEWORK</td>
</tr>
<tr>
<td>A9.7.3</td>
<td>CUSTOM ARCHITECTURAL CASEWORK</td>
</tr>
<tr>
<td>A9.7.4</td>
<td>CUSTOM ARCHITECTURAL CASEWORK</td>
</tr>
<tr>
<td>A9.7.5</td>
<td>CUSTOM ARCHITECTURAL CASEWORK</td>
</tr>
<tr>
<td>A9.8.1</td>
<td>INTERIOR GLASS DETAILS</td>
</tr>
<tr>
<td>A9.8.2</td>
<td>INTERIOR GLASS DETAILS</td>
</tr>
<tr>
<td>A9.9.1</td>
<td>MISCELLANEOUS INTERIOR DETAILS</td>
</tr>
<tr>
<td>A9.9.2</td>
<td>CORNER AND WALL GUARD DETAILS</td>
</tr>
<tr>
<td>A9.9.3</td>
<td>MISCELLANEOUS RESTROOM DETAILS</td>
</tr>
<tr>
<td>A9.9.4</td>
<td>MISCELLANEOUS ACOUSTICAL DETAILS</td>
</tr>
<tr>
<td>A11.1.1</td>
<td>LEVEL 1 SIGNAGE PLAN</td>
</tr>
<tr>
<td>A11.1.2</td>
<td>LEVEL 2 SIGNAGE PLAN</td>
</tr>
<tr>
<td>A11.1.3</td>
<td>LEVEL 3 SIGNAGE PLAN</td>
</tr>
<tr>
<td>A11.1.4</td>
<td>ROOF SIGNAGE PLAN</td>
</tr>
<tr>
<td>A11.2.1</td>
<td>SIGNAGE TYPES</td>
</tr>
<tr>
<td>A11.3.1</td>
<td>SIGNAGE ELEVATIONS</td>
</tr>
</tbody>
</table>

### LABORATORY

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF001</td>
<td>LABORATORY FURNISHINGS KEY SHEET</td>
</tr>
<tr>
<td>LF002</td>
<td>LABORATORY FURNISHINGS FITTING AND EXHAUST SCHEDULE</td>
</tr>
<tr>
<td>LF003</td>
<td>LABORATORY FURNISHINGS CASEWORK MENU</td>
</tr>
<tr>
<td>LF004</td>
<td>CASEWORK ANCHORAGE DETAILS</td>
</tr>
<tr>
<td>LF100</td>
<td>LABORATORY FURNISHINGS LEVEL 1 OVERALL PLAN</td>
</tr>
<tr>
<td>LF101</td>
<td>LABORATORY FURNISHINGS LEVEL 1 PARTIAL PLAN A</td>
</tr>
<tr>
<td>LF102</td>
<td>LABORATORY FURNISHINGS LEVEL 1 PARTIAL PLAN B</td>
</tr>
<tr>
<td>LF200</td>
<td>LABORATORY FURNISHINGS LEVEL 2 OVERALL PLAN</td>
</tr>
<tr>
<td>LF201</td>
<td>LABORATORY FURNISHINGS LEVEL 2 PARTIAL PLAN A</td>
</tr>
<tr>
<td>LF202</td>
<td>LABORATORY FURNISHINGS LEVEL 2 PARTIAL PLAN B</td>
</tr>
<tr>
<td>LF300</td>
<td>LABORATORY FURNISHINGS LEVEL 3 OVERALL PLAN</td>
</tr>
<tr>
<td>LF301</td>
<td>LABORATORY FURNISHINGS LEVEL 3 PARTIAL PLAN A</td>
</tr>
<tr>
<td>LF302</td>
<td>LABORATORY FURNISHINGS LEVEL 3 PARTIAL PLAN B</td>
</tr>
<tr>
<td>LF303</td>
<td>LABORATORY FURNISHINGS LEVEL 3 PARTIAL PLAN C</td>
</tr>
<tr>
<td>LF400</td>
<td>LABORATORY FURNISHINGS INTERIOR ELEVATIONS</td>
</tr>
<tr>
<td>LF401</td>
<td>LABORATORY FURNISHINGS INTERIOR ELEVATIONS</td>
</tr>
<tr>
<td>LF500</td>
<td>LABORATORY FURNISHINGS EXHAUST DETAILS</td>
</tr>
<tr>
<td>LF501</td>
<td>LABORATORY FURNISHINGS DETAILS</td>
</tr>
<tr>
<td>LF502</td>
<td>LABORATORY FURNISHINGS DETAILS</td>
</tr>
<tr>
<td>LF503</td>
<td>LABORATORY FURNISHINGS DETAILS</td>
</tr>
</tbody>
</table>
MECHANICAL

M0.01  MECHANICAL LEGEND, ABBREVIATIONS, AND GENERAL NOTES
M0.02  MECHANICAL SCHEDULES
M0.03  MECHANICAL SCHEDULES
M0.04  MECHANICAL SCHEDULES
M0.05  MECHANICAL SCHEDULES
M2.01  MECHANICAL - LEVEL 1 FLOOR PLAN
M2.01A MECHANICAL - LEVEL 1 PARTIAL PLAN A
M2.02  MECHANICAL - LEVEL 2 FLOOR PLAN
M2.02A MECHANICAL - LEVEL 2 PARTIAL PLAN A
M2.02B MECHANICAL - LEVEL 2 PARTIAL PLAN B
M2.03  MECHANICAL - LEVEL 3 FLOOR PLAN
M2.03A MECHANICAL - LEVEL 3 PARTIAL PLAN A
M2.03B MECHANICAL - LEVEL 3 PARTIAL PLAN B
M2.04  MECHANICAL - ROOF PLAN
M3.01  MECHANICAL - LEVEL 1 HYDRONIC
M3.01A HYDRONIC - LEVEL 1 PARTIAL PLAN A
M3.02  MECHANICAL - LEVEL 2 HYDRONIC
M3.02A HYDRONIC - LEVEL 2 PARTIAL PLAN A
M3.02B HYDRONIC - LEVEL 2 PARTIAL PLAN B
M3.03  MECHANICAL - LEVEL 3 HYDRONIC
M3.03A HYDRONIC - LEVEL 3 PARTIAL PLAN A
M3.03B HYDRONIC - LEVEL 3 PARTIAL PLAN B
M3.04  MECHANICAL - ROOF HYDRONIC
M4.01  MECHANICAL ENLARGED PLANS
M4.02  MECHANICAL ENLARGED PLANS
M5.01  MECHANICAL AIRSIDE DIAGRAM
M5.02  MECHANICAL HYDRONIC DIAGRAM
M6.01  MECHANICAL DETAILS
M6.02  MECHANICAL DETAILS
M6.03  MECHANICAL DETAILS
M6.04  MECHANICAL DETAILS
M6.05  MECHANICAL DETAILS
M6.06  MECHANICAL DETAILS
M6.07  MECHANICAL DETAILS
M7.01  MECHANICAL CONTROLS
M7.02  MECHANICAL CONTROLS
M7.03  MECHANICAL CONTROLS
M7.04  MECHANICAL CONTROLS
M7.05  MECHANICAL CONTROLS
M8.01  MECHANICAL T24
M8.02  MECHANICAL T24
M8.03  MECHANICAL T24
M8.04  MECHANICAL T24
M8.05  MECHANICAL T24

PLUMBING

P0.01  PLUMBING LEGEND, ABBREVIATIONS, AND GENERAL NOTES
P0.02  PLUMBING SCHEDULES
P1.01  PLUMBING - SITE PLAN
P2.00  PLUMBING - UNDERGROUND PLAN
FIRE ALARM

FA0.01 FIRE ALARM GENERAL NOTES, LEGEND
FA0.02 FIRE ALARM SCHEDULES
FA1.01 FIRE ALARM - SITE PLAN
FA2.01 FIRE ALARM - LEVEL 1 FLOOR PLAN
FA2.02 FIRE ALARM - LEVEL 2 FLOOR PLAN
FA2.03 FIRE ALARM - LEVEL 3 FLOOR PLAN
FA2.04 FIRE ALARM - ROOF PLAN
FA4.01 FIRE ALARM - ENLARGED PLANS
FA5.01 FIRE ALARM DIAGRAM
FA5.02 COMMUNICATION DIAGRAM
FA5.03 FIRE ALARM BATTERY CALCULATIONS
FA6.01 FIRE ALARM DETAILS

FIRE PROTECTION

F0.0.1 FIRE PROTECTION TITLE SHEET
F0.0.2 FIRE PROTECTION MISC. DETAILS
F0.0.3 FIRE PROTECTION MISC. DETAILS
F0.0.4 FIRE PROTECTION HANGER DETAILS
F0.0.5 FIRE PROTECTION SWAY BRACE DETAILS
F1.0.0 FIRE PROTECTION REFERENCE UNDERGROUND PIPING PLAN
F2.1.1 FIRE PROTECTION REFLECTED CEILING PLAN - LEVEL 1
F2.1.2 FIRE PROTECTION REFLECTED CEILING PLAN - LEVEL 2
F2.1.3 FIRE PROTECTION REFLECTED CEILING PLAN - LEVEL 3 & SKY OBSERVATORY
F3.1.1 FIRE PROTECTION OVERHEAD PIPING PLAN - LEVEL 1
F3.1.2 FIRE PROTECTION OVERHEAD PIPING PLAN - LEVEL 2
F3.1.3 FIRE PROTECTION OVERHEAD PIPING PLAN - LEVEL 3
F3.1.4 FIRE PROTECTION OVERHEAD PIPING PLAN - ROOF & SKY OBSERVATORY
F4.1.1 FIRE PROTECTION BUILDING SECTION
ELECTRICAL

E0.01 ELECTRICAL LEGEND
E0.02 ELECTRICAL GENERAL NOTES AND ABBREVIATIONS
E0.03 LIGHTING FIXTURE SCHEDULES
E0.04 LIGHTING FIXTURE SCHEDULES
E0.05 EQUIPMENT SCHEDULES
E0.06 DISTRIBUTION PANEL SCHEDULES
E0.07 PANEL SCHEDULES
E0.08 PANEL SCHEDULES
E0.09 PANEL SCHEDULES
E0.10 PANEL SCHEDULES
E0.11 PANEL SCHEDULES
E0.12 PANEL SCHEDULES
E1.01.V2 ELECTRICAL - SITE PLAN
E1.02.V2 LIGHTING - SITE PLAN
E1.03 LIGHTING - SITE PLAN LEVEL 2
E1.11 ELECTRICAL - ENLARGED SITE PLAN
E1.13.V2 ELECTRICAL - MANHOLE, DUCT BANK DETAIL
E2.01 LIGHTING - LEVEL 1 FLOOR PLAN
E2.02 LIGHTING - LEVEL 2 FLOOR PLAN
E2.03 LIGHTING - LEVEL 3 FLOOR PLAN
E2.04 LIGHTING - ROOF PLAN
E2.05 LIGHTING - SKY DECK PLAN
E2.06 LIGHTING - STAIRS
E3.00 POWER - UNDERGROUND PLAN
E3.01 POWER - LEVEL 1 FLOOR PLAN
E3.01A POWER - LEVEL 1 PARTIAL PLAN A
E3.02 POWER - LEVEL 2 FLOOR PLAN
E3.02A POWER - LEVEL 2 PARTIAL PLAN A
E3.02B POWER - LEVEL 2 PARTIAL PLAN B
E3.03 POWER - LEVEL 3 FLOOR PLAN
E3.03A POWER - LEVEL 3 PARTIAL PLAN A
E3.03B POWER - LEVEL 3 PARTIAL PLAN B
E3.04 POWER - ROOF PLAN
E3.05 POWER - SKY DECK PLAN
E4.01 ENLARGED ROOM PLANS
E4.02 ENLARGED ROOM PLANS
E4.03 ENLARGED ROOM PLANS
E5.00 SINGLE LINE DIAGRAM - MEDIUM VOLTAGE
E5.01 SINGLE LINE DIAGRAM - LOW VOLTAGE
E5.02 RISER DIAGRAM - GROUNDING
E6.01 ELECTRICAL DETAILS
E6.02 ELECTRICAL DETAILS
E6.03 ELECTRICAL DETAILS
E6.04 ELECTRICAL DETAILS
E6.05 ELECTRICAL DETAILS
E6.06 ELECTRICAL DETAILS
E6.07 ELECTRICAL DETAILS
E6.08 ELECTRICAL DETAILS
E6.09 ELECTRICAL DETAILS
E6.10 ELECTRICAL DETAILS
E6.11 ELECTRICAL DETAILS
E6.12 ELECTRICAL DETAILS
E6.13 ELECTRICAL DETAILS
E6.14 ELECTRICAL DETAILS
E6.15 ELECTRICAL DETAILS
E6.16 ELECTRICAL DETAILS
E6.17 ELECTRICAL DETAILS
E6.18 ELECTRICAL DETAILS
E6.19 ELECTRICAL DETAILS
E6.20 ELECTRICAL DETAILS
E6.21 ELECTRICAL DETAILS
E6.22 ELECTRICAL DETAILS
E6.23 ELECTRICAL DETAILS
E6.24 ELECTRICAL DETAILS
E6.25 ELECTRICAL DETAILS
E7.01 ELECTRICAL T24
E7.02 ELECTRICAL T24
E7.03 ELECTRICAL T24

TECHNOLOGY
T0.0.1.V2 TITLE SHEET AND INDEX
T0.0.2.V2 PATHWAY REQUIREMENTS
T0.0.3 SCHEDULES
T0.1.1 DIAGRAM - BACKBONE PATHWAYS
T0.1.2 DIAGRAM - GROUNDING
T0.1.3 DIAGRAM - CABLING
T0.2.1 DIAGRAM - SECURITY ACAMS BLOCK
T0.2.2 DIAGRAM - SECURITY VSS BLOCK
T0.3.1 DIAGRAM - AV FUNCTIONALS
T0.3.2 DIAGRAM - AV FUNCTIONALS
T2.0.1 FLOOR PLAN - LEVEL 1
T2.0.2 FLOOR PLAN - LEVEL 2
T2.0.3 FLOOR PLAN - LEVEL 3
T2.0.4 FLOOR PLAN - ROOF
T2.0.5 FLOOR PLAN - SUNKEN ROOF - MEZZANINE STAIRWELL
T2.0.6 FLOOR PLAN - OBSERVATORY
T3.0.1 REFLECTED CEILING PLAN - LEVEL 1
T3.0.2 REFLECTED CEILING PLAN - LEVEL 2
T3.0.3 REFLECTED CEILING PLAN - LEVEL 3
T4.0.0 ROOM PLANS & EQUIPMENT ELEVATION - BDF 128
T4.0.1 ROOM PLANS & EQUIPMENT ELEVATION - IDF ROOM TYPICAL
T4.0.10 ROOM PLAN - 72 OCC CLASSROOM
T4.0.11 ROOM ELEVATIONS - 72 OCC CLASSROOM
T4.0.12 ROOM PLAN - 50 OCC CLASSROOM
T4.0.13 ROOM ELEVATIONS - 50 OCC CLASSROOM
T4.0.14 ROOM PLAN - 40 OCC CLASSROOM
T4.0.15 ROOM ELEVATIONS - 40 OCC CLASSROOM
T4.0.16 ROOM PLAN - 36 OCC CLASSROOM
T4.0.17 ROOM ELEVATIONS - 36 OCC CLASSROOM
T4.0.18 ROOM PLAN - ANATOMY LAB
T4.0.19 ROOM ELEVATIONS - ANATOMY LAB
T4.0.20 ROOM PLAN - PHYSIO LAB
T4.0.21 ROOM ELEVATIONS - PHYSIO LAB
T4.0.22 ROOM PLAN - MICROBIO LAB
T4.0.23 ROOM ELEVATIONS - MICROBIO LAB
T4.0.24 ROOM PLAN - BIOTECH LAB
T4.0.25 ROOM ELEVATIONS - BIOTECH LAB
T4.0.26 ROOM PLAN - COMPUTER LAB
T4.0.27 ROOM ELEVATIONS - COMPUTER LAB
T4.0.28 ROOM PLAN - GEN BIO LAB
T4.0.29 ROOM ELEVATIONS - GEN BIO LAB
T4.0.30 ROOM PLAN - MEETING ROOM
T4.0.31 ROOM PLAN - O-CHEM LAB
T4.0.32 ROOM ELEVATIONS - O-CHEM LAB
T4.0.33 ROOM PLAN - CHEMISTRY LAB B
T4.0.34 ROOM ELEVATIONS - CHEMISTRY LAB B
T4.0.35 ROOM PLAN - ENGINEERING LAB
T4.0.36 ROOM ELEVATIONS - ENGINEERING LAB
T4.0.37 ROOM PLAN - PHYSICS LAB
T4.0.38 ROOM ELEVATIONS - PHYSICS LAB
T4.0.39 ROOM PLAN - PLANETARIUM
T4.0.40 ROOM PLAN - PLANETARIUM
T4.0.41 ROOM PLAN - 36 OCC CLASSROOM 113
T4.0.42 ROOM ELEVATIONS - 36 OCC CLASSROOM 113
T4.0.43 ROOM PLAN - INTRO CHEM LAB
T4.0.44 ROOM ELEVATIONS - INTRO CHEM LAB
T5.1.1 DETAILS - TELECOM
T5.1.2 DETAILS - TELECOM
T5.1.3 DETAILS - TELECOM
T5.1.4 DETAILS - TELECOM
T5.2.1 DETAILS - SECURITY
T5.2.2 DETAILS - SECURITY
T5.3.1 DETAILS - AUDIOVISUAL

PLANETARIUM
PL.A1 PLANETARIUM ACOUSTIC TREATMENT (DEFERRED SUBMITTAL)
PL.EQ1 PLANETARIUM 30 FT DIAMETER PROJECTION DOME SUSPENSION (DEFERRED SUBMITTAL)
PL.EQ2 PLANETARIUM 5.1 SOUND SYSTEM WITH PA (DEFERRED SUBMITTAL)
PL.EQ3 PLANETARIUM EQUIPMENT LOCATION (DEFERRED SUBMITTAL)
PL.EQ4 PLANETARIUM CONTROL CONSOLE AND CENTRAL BARRIER (DEFERRED SUBMITTAL)
PL.RE1 PLANETARIUM ELECTRICAL REQUIREMENTS (REFERENCE ONLY)
PL.RE2 PLANETARIUM LED DOME LIGHTING REQUIREMENTS (DEFERRED SUBMITTAL)
PL.TE1 PLANETARIUM AUDIO, VISUAL, AND LIGHTING BLOCK DIAGRAMS (DEFERRED SUBMITTAL)

END OF SECTION 00010
SECTION 024113 - SELECTIVE SITE DEMOLITION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes all work necessary to successfully complete demolition to prepare site for the phasing and new construction, including the following:

   1. Clean line saw cutting of existing asphalt pavement, concrete sidewalks, concrete curb/gutter, etc., as specified herein.
   2. Protection from injury or defacement existing building elements to be preserved.
   3. Removal of debris and deleterious materials such as rubbish.
   4. Removal and stockpile of materials for landscaping use at approved location.
   5. Disposal of unwanted or objectionable materials off site.
   6. Disconnecting, capping or sealing, and abandoning site utilities in place.
   7. Disconnecting, capping or sealing, and removing site utilities.
   8. Removing above-grade site improvements within limits indicated.

1.2 REGULATORY REQUIREMENTS:

A. No burning shall be allowed.

B. Do not use explosives.

C. Comply with the following California Code of Regulations:

   1. Title 8: CAL/OSHA, Chapter, Subchapter 4 – Construction Safety Orders.
   2. Title 24: Part 2, California Building Code, Chapter 33, Protection of Pedestrian during Construction or Demolition.
   3. Bay Area Air Quality Management District.

1.3 DEFINITIONS


B. CAL-OSHA: California Occupational Safety and Health Administration.


E. EPA: Environmental Protection Agency.


G. Remove: Detach items from existing construction and legally dispose of them off-site unless they indicated to be removed and salvaged or recycled.

H. Remove and Salvage: Detach items from existing construction, prior to demolition, and deliver
them to the District.

I. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed and salvaged, or recycled.

### 1.4 SUBMITTALS

A. Follow Submittal procedure outlined in Division 0 – General Conditions and Division 1 – General Requirements.

B. For LEED criteria related to waste management, follow the procedure outlined in section 018113 “Sustainability Design Requirements”.

### 1.5 PROJECT CONDITIONS

A. In all circumstances ensure that demolition work does not adversely affect adjacent water courses, groundwater and wildlife, or contribute to excess air and noise pollution.

B. Do not dispose, of waste or volatile materials such as mineral spirits, oil, petroleum based lubricants, or toxic cleaning solutions into watercourses, storm or sanitary sewers. Ensure proper disposal procedures are maintained throughout project.

C. Do not pump water containing suspended materials into watercourses, storm or sanitary sewers, or onto adjacent properties.

D. Control disposal or runoff of water containing suspended materials or other harmful substances in accordance with local authorities.

E. Protect trees, plants and foliage on site and adjacent properties where indicated.

F. Except for materials indicated to be stockpiled or to remain, cleared materials are the Contractor’s property. Remove cleared materials from site and dispose of in lawful manner.

### PART 2 - PRODUCTS

#### 2.1 SOIL MATERIALS

A. Backfill excavations resulting from demolition operations with on-site or import materials conforming to structural backfill defined in Section 31 23 33 Utility Trenching and Backfill.

### PART 3 - EXECUTION

#### 3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points during construction.

B. Protect existing site improvements to remain during construction.
C. Provide the following temporary facilities to facilitate the demolition operations, as necessary:
   1. Temp Traffic Controls
   2. Protection of Persons and Property
   3. Protection of Utilities
   4. Protection of Trees
   5. Noise and Dust Abatement
   6. Clear and restore area to their original condition
   7. Protect existing site improvements and adjacent structures from removal and damage.
   8. Protect and maintain benchmarks and survey control points during construction.

3.2 RESTORATION

A. Restore areas and existing works outside areas of demolition to match conditions to their original condition, as acceptable to the District.

B. Restore damaged improvements to their original condition, as acceptable to the District.

3.3 UTILITIES

A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed or abandoned.

B. Arrange to shut off indicated utilities with utility companies or verify that utilities have been shut off.

C. Existing Utilities: Do not interrupt utilities serving facilities occupied by District or others unless authorized in writing by the District and then only after arranging to provide temporary utility services according to requirements indicated.

D. Coordinate utility interruptions with District.

E. Do not proceed with utility interruptions without the permission of the District and utility company affected. Notify the District and the utility company affected 14 working days prior to utility interruptions.

F. Excavate and remove underground utilities that are indicated to be removed.

G. Securely close ends of abandoned piping with tight fitting plug or wall of concrete minimum 6-inches thick.

H. Adjustment of manhole frames and other castings Caltrans Standard Specifications Sec 15-2.05A.

3.4 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, and gutters, as indicated. Where concrete slabs, curb, gutter and asphalt pavements are designated to be removed, remove bases and subbase to surface of underlying, undisturbed soil.
C. Unless the existing full-depth joints coincide with line of pavement demolition, neatly saw-cut to full depth the length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.

D. Remove driveways, curbs, gutters and sidewalks by saw cutting to full depth. If saw cut falls within 30-inches of a construction joint, expansions joint, score mark or edge, remove material to joint, mark or edge.

3.5 SALVAGED IMPROVEMENTS

A. Salvaged Improvements: Carefully remove items indicated to be salvaged and store where indicated on plans or where designated by the District. Avoid damaging materials designated for salvage.

3.6 DISPOSAL

A. Remove surplus obstructions, demolished materials, and waste materials, including trash and debris, and legally dispose of them off the District’s property.

B. Remove: Unless items are otherwise to remain or be reinstalled, remove and dispose of items. Do not store removed items that are of value to the contractor on site.

C. Remove and Reinstall: Remove items; clean, service and otherwise prepare for service; reinstall in the same location (or in the location shown on drawings).

D. Unidentified Materials: Unidentified materials, including hazardous materials that will require additional removal other than is required by the Contract Documents, are located in some underground utilities. Immediately report the discovery to the District. If necessary, the District will arrange for any testing or analysis of the discovered materials and will provide instructions regarding the removal and disposal of the unidentified materials.

3.7 CONSTRUCTION WASTE MANAGEMENT

A. Separate reusable and recyclable products from contaminated waste and debris in accordance with the General Contractor’s Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

B. For LEED criteria related to waste management, follow the procedure outlined in section 018113 “Sustainability Design Requirements”.

END OF SECTION
SECTION 030413 - COMMON SUBMITTAL REQUIREMENTS FOR CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
   a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Refer to Section 01330 for quantity of days allowed for review.
2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER’S AND GENERAL CONTRACTOR’S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect’s staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect’s notations and Contract Document requirements.
d. **Code AN-R - Approved as Noted - Resubmit:** Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. **Action Code Prohibiting Use:**
   a. **Action Code REJ - Not Approved:** The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. **Action Code for Items Not Required:**
   a. **Action Code X - Not Requested by Contract Documents:** The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. **Informational Submittals:** For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. **Action Code for Information Only:**
   a. **Action Code INF - Information Only - Received:** The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 **SUBMITTAL TRANSMITTAL REQUIREMENTS**

A. **Submittal Transmittal shall be a PDF file in electronic format.** It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
   1. **Submittal Numbering:** See below.
   2. **Contact Information:** Full Name, Phone Number and Email Address.

B. **Submittal Definition**
   1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering

1. Number submittals as described below to assist tracking.

2. Number each submittal in the format nnnnnn-nn.

   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.

   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.

   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.

   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.

   e. Examples:


3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:

   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 031100 - CONCRETE FORMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Responsibility for design, engineering, construction, maintenance, completeness, safety, and adequacy of removable formwork.
   2. Formwork required for cast-in-place concrete, with shoring, bracing and anchorage.
   3. Items, materials, operations and methods including labor, equipment and incidentals.
   4. Coordinate installation of items furnished under other sections.

B. Related Sections:
   1. Section 031500 - Concrete Accessories.
   2. Section 032000 - Concrete Reinforcement.
   3. Section 033000 - Cast-in-Place Concrete.
   4. Section 053100 - Steel Decking.

1.2 REFERENCES

B. ACI 301 - Specifications for Structural Concrete for Buildings.
C. ACI 318 - Building Code Requirements for Structural Concrete.
D. ACI 347 - Guide to Formwork for Concrete.
E. PS1 - Construction and Industrial Plywood.
F. AISC Code of Standard Practice for Steel Buildings and Bridges

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Submit shop drawings, prepared by or under the supervision of a qualified professional engineer and the provisions of this Section. Design and engineering of formwork are Contractor's responsibility.
   1. Include plans, elevations, sections and complete details to clearly describe, at ample scale, all work to be provided. Detail openings, curbs, pads, trenches, sleeves, and other formed features for all items shown or referred to in the contract documents.
   2. Indicate locations and spacings of form ties in exposed finish concrete.

C. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.
   1. Location of construction joints is subject to approval.
1.4 INFORMATIONAL SUBMITTALS

A. Material Certificates: For each of the following, signed by manufacturers:
   1. Form materials and form-release agents

1.5 QUALITY ASSURANCE

A. Applicable Standards: ACI 347 "Guide to Formwork for Concrete" and ACI 301 "Specifications for Structural Concrete for Buildings".

B. Allowable Tolerances: Design, construct and maintain formwork to insure completed work within tolerance limits specified in ACI 301 and ACI 117, unless more stringent tolerances are given in this specification, with stipulation that no tolerances specified for horizontal or vertical building lines or footings should be construed to permit encroachment beyond legal boundaries.

PART 2 - PRODUCTS

2.1 FORM-FACING MATERIALS

A. General: Provide formwork units with sufficient thickness and stiffness to resist plastic concrete loads without detrimental deformation.

B. Forms for Exposed Smooth-Formed Finish Concrete: Construct formwork for exposed concrete surfaces with form-facing panels that will provide continuous, true, and smooth exposed concrete surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on Drawings. Form corners with 3/4 inch by 3/4 inch chamfer strips, mitered at changes in direction.
   1. Plywood, metal, or other approved panel materials
   2. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
      a. B-B (Concrete Form), Class 1 or better, mill oiled and edge sealed.

C. Forms for Unexposed Rough-Formed Finish Concrete: Form concrete surfaces which will be unexposed in finished structure with plywood, lumber, metal or other acceptable material. Provide lumber dressed on at least 2 edges and one side for tight fit.

D. Backing for Forms: Structurally sound lumber or metal frame, solid, straight and free of defects that may impair its strength.

E. Forms for Cylindrical Columns, Pedestals and Supports:
   1. Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that will produce surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class.
   2. Reusable round column forms made from fiberglass. Flanges on each side of vertical joints shall be pre-drilled for exact alignment and fitted with bolts and wedges. They shall be constructed to ensure specified formwork surface class.

F. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.
2.2 ACCESSORIES FOR REMOVABLE FORMS

A. Form Ties: Factory-fabricated, adjustable-length, removable or snap-off metal or glass-fiber-reinforced plastic form ties, designed to resist lateral pressure of fresh concrete on forms without form deflection, and to prevent spalling concrete surfaces upon removal.
   1. Provide ties so that portion remaining within concrete after removal of exterior parts is at least one inch from outer concrete surface.
   2. Spreader cones on ties shall not be larger than one inch in diameter.
   3. At exposed finish concrete provide form ties with plastic cones and plastic setback plugs, color as selected, with equal spacing in horizontal and vertical line.
   4. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

B. Chamfer and Reveal or Recess Strips: Wood, metal, PVC, or rubber strips. Triangular chamfer strips shall be 3/4 inch by 3/4 inch. Round chamfer strips shall have 3/4 inch radius. Size reveal or recess strips as noted. Wood strips shall have planed faces.

C. Rustification Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.

D. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatment of surfaces requiring bond or adhesion, nor impede wetting of surfaces to be cured with water or curing compounds.

PART 3 - EXECUTION

3.1 DESIGN

A. Removable Forms: Design for vertical and lateral loads and pressures, including static, dynamic and construction loads, as outlined in the ACI Standard “Guide to Formwork for Concrete” (ACI 347). Contractor is solely responsible for the design, engineering, construction, maintenance, completeness, safety, and adequacy of all removable formwork.

B. Tolerances: Design formwork so concrete members and structures are of size, shape, alignment, elevation and position indicated, within allowable tolerances of ACI 117 or those specified.

C. Surface Irregularities: Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
   1. Class C, 1/2 inch – General conditions.
   2. Class D, 1 inch – Foundations permanently concealed to view.

D. Openings: Design formwork with temporary openings at locations as required for inspections and to permit removal of extraneous materials before placing concrete.

E. Removal: Design forms for safety in removal and with proper sequence without damage to concrete. Forms should be easily removed without hammering or prying against concrete surfaces.
F. Adjustment: Design positive means of adjustment (wedges or jacks) for shores and struts to correct settlements or facilitate dismantling of formwork.

G. Foundation: Design satisfactory foundations for formwork supported on ground to carry loads imposed during construction, without appreciable settlement.

H. Joints: Design with minimum number of joints and with joints sufficiently tight to prevent leakage of grout or cement paste.

3.2 ERECTION OF REMOVABLE FORMS

A. Verify lines, levels, measurements, elevation and center locations before proceeding with formwork.

B. Provide for openings, offsets, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages, inserts and other features required. Determine sizes and locations from trades providing such items.

C. Construct forms of materials selected to obtain required finishes.

D. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces.

E. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical or where slope is too steep to place concrete with bottom forms only.

F. Kerf wood inserts used for forming keyways, recesses, and similar features to prevent swelling and assure ease of removal.

G. Do not use rust-stained steel form-facing material.

H. Locate temporary openings in forms as inconspicuous as possible, consistent with project requirements. Brace closures and set tightly to forms to prevent loss of concrete mortar.

I. Provide permanent openings in forms where shown or required to accommodate other work, including Mechanical and Electrical Work.

J. Erect, support, brace and maintain formwork and falsework to safely support vertical, lateral, and asymmetrical loads and forces until they can be supported by in-place concrete structures.

K. Set edge forms or bulkheads and intermediate screed strips for slabs to achieve required elevations and contours in finished slab surfaces. Provide and secure units to support types of screeds required.

L. For exposed concrete, drill forms to suit approved ties and spacings and to prevent leakage of mortar around tie holes. Do not splinter forms by driving ties through improperly prepared holes.

M. For exposed concrete, do not use metal cover plates to patch holes or defects in forms.

N. Chamfer exterior corners and edges of permanently exposed concrete.

O. At intersecting planes provide sharp, clean corners without visible edges or offsets and back joints with extra studs or girts to maintain true, square intersections.
P. At changes in plane, form molding shapes, recesses and projections with smooth-finish materials, and install in forms with sealed joints to prevent displacement.

Q. Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt or other debris before concrete is placed. During cold weather be sure that ice and snow has been removed.

R. Retighten forms, if necessary, before and immediately after concrete is placed to eliminate mortar leaks and to maintain proper alignment. Carefully inspect falsework and formwork during and after concrete placement operations to determine abnormal deflections or signs of possible failure and make necessary adjustments to produce work of required dimensions.

S. Do not displace or damage vapor retarder.

3.3 EMBEDDED ITEMS

A. Accurately place and securely support anchorage devices and other embedded items required for adjoining work that is attached to, or supported by, cast-in-place concrete. Use setting drawings, templates, diagrams, instructions and directions furnished with items to be embedded.

B. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC’s “Code of Standard Practice for Steel Buildings and Bridges.”

C. Install reglets to receive waterproofing and to receive through-wall flashing in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions, or as indicated in drawings.

D. Install dovetail anchor slots in concrete structures as indicated.

E. Install “formsaver” reinforcement couplers only where explicitly illustrated on Drawings or approved in advance for specific applications.

3.4 WATERSTOPS

A. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated, according to manufacturer's written instructions, adhesive bonding, mechanically fastening and firmly pressing into place. Install in longest lengths practicable.

3.5 APPLICATION OF FORM RELEASE AGENT

A. Apply form release agent on formwork in accordance with manufacturer's instructions. Do not allow excess form release agent to accumulate in forms or come into contact with surfaces which will be bonded to fresh concrete. Apply prior to placing reinforcing steel, anchoring devices, and embedded items.

B. Do not apply form release agent where concrete surfaces are scheduled to receive special finishes or applied coverings which may be affected by agent. Soak contact surfaces of untreated forms with clean water. Keep surfaces wet prior to placing concrete.
C. Do not apply form release agent where wood graining characteristics are required on finished concrete surfaces. Leave formwork dry.

3.6 FORM REMOVAL AND REUSE

A. Do not remove forms, shores and bracing until concrete has gained sufficient strength to carry its own weight, construction live loads, and lateral loads which are liable to be imposed upon them without damage, overstress, or excessive deflection.

1. Remove load-supporting forms only when concrete has attained 75 percent of required 28 day compressive strength, provided construction is reshored.

B. Remove formwork progressively and in accordance with code requirements so that no shock loads or unbalanced loads are imposed on structure.

C. Forms not directly supporting weight of concrete may be removed after cumulatively curing at not less than 50 degrees F for 24 hours after placing concrete. Concrete has to be hard enough to not be damaged by form-removal operations and curing and protection operations need to be maintained.

D. Loosen forms carefully. Do not wedge pry bars, hammers, or tools against concrete surfaces. Repair or replace, as directed, all damaged work.

E. Clean and repair surfaces of forms to be reused. Store removed forms used for exposed concrete in manner that surfaces to be in contact with fresh concrete will not be damaged. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for reuse on exposed surfaces.

F. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Architect.

G. Earth retaining walls: Do not backfill against walls until all work is in place which braces the top and bottom of walls against lateral displacement and until concrete has attained its design strength.

3.7 SHORES AND RESHORES

A. Comply with recommendations in ACI 347R and ACI 301 for design, installation, and removal of shoring and reshoring.

1. Do not remove shoring or reshoring until measurement of slab tolerance is complete.

B. Reshore structural members where required due to design requirements or construction conditions and as required to permit progressive construction. Contractor must perform at no cost to Owner, all tests and calculations needed to show when forms, formwork supports, shores and re-shores can be removed without endangering the structure.

C. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.
3.8 FIELD QUALITY CONTROL

A. Inspection is subject to compliance with requirements affecting finish results only. Adequacy of formwork and shores to support necessary vertical and lateral loads and pressures is sole responsibility of Contractor.

B. Testing and Inspection: Owner will engage qualified special inspectors in accordance with Section 01 45 33.
   1. Qualifications: The minimum category of special inspector required to perform services outlined below are noted by qualifications in parentheses. The definitions of the categories of special inspector are included in Section 01 45 33.

C. On a periodic basis, verify formwork for all concrete, excluding slabs on grade, strip footings without transverse reinforcement and topping slabs, will result in member size, location and configuration as described on the contract documents, only as it affects the structural integrity of the concrete elements to be placed. (Technical II)

END OF SECTION
SECTION 031500 - CONCRETE ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Concrete accessories and related materials for cast-in-place concrete.
   2. Coordinate Work in this Section with requirements of Section 03 11 00 and 03 30 00.

B. Related Sections:
   1. Section 031100 - Concrete Forming.
   2. Section 032000 - Concrete Reinforcing.
   3. Section 033000 - Cast-in-Place Concrete.
   4. Section 079200 - Joint Sealants.

1.2 SUBMITTALS

A. Product Data: For each product.

B. Certificates: Provide a letter stating each product specified in this Section has been evaluated and found compatible with other sections.

PART 2 - PRODUCTS

2.1 UNDERSLAB VAPOR BARRIERS

A. (UVB-3) Under-Slab Vapor Barrier: ASTM E 1745, Class A, except with maximum water vapor permeance of less than 0.01 perms before and after conditioning tests per ASTM E 1745, Sections 7.1.1 - 7.1.5.
   1. Minimum Thickness, ACI 302: 15-mil
   2. Maximum Water Vapor Permeance, ASTM E 154: 0.01 perms
   4. Puncture Resistance, ASTM D 1709: 2200 grams
   5. Manufacturers and Products:
      a. Epro Services: Ecoshield E15
      b. Raven Industries: VaporBlock VBLP15.
      c. Reef Industries: Griffolyn 15 Mil Green.
      d. Stego Industries: Stego Wrap 15 mil.
      e. Viper: VaporCheck II 15 mil.

B. Vapor Barrier Accessories: Provide accessories manufactured by or recommended in writing by vapor barrier Manufacturer for sealing seams, penetrations and perimeter edges, including; seam tape, mastics, edge termination bar, double-sided tape, and other special tapes and accessories for complete under-slab vapor barrier assembly.
1. Seam Tape: 4-inch minimum width; water vapor transmission less than 0.3 perms per ASTM F 1249 or ASTM E 96.
2. Pipe Boots: Construct pipe boots from vapor barrier material and pressure sensitive tape in accordance with Manufacturer's instructions.

2.2 EXPANSION JOINT FILLERS


B. Expansion Joint Fillers (Backing for Sealant): Flexible, compressible, closed-cell polyethylene foam, not less than 10 psi compression deflection.

2.3 WATERSTOPS

A. Self-Expanding Strip Waterstops: Manufactured rectangular or trapezoidal strip, sodium bentonite or other hydrophylic material for adhesive bonding to concrete.

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
   a. Volclay Waterstop-RX; Colloid Environmental Technologies Co.
   b. Conseal CS-231; Concrete Sealants Inc.
   c. Swellseal Joint; De Neef Construction Chemicals (U.S.) Inc.
   d. Hydrotite; Greenstreak.
   e. Superstop; Progress Unlimited Inc.

B. Provide factory fabricated waterstop intersections, leaving only straight butt joint splices for the field.

2.4 INSERTS

A. Dovetail Anchor Slots: Fabricate from not less than 22 gauge galvanized steel with one inch wide back by one inch deep with 5/8 inch throat. Nail holes 4 inch o.c.

1. Provide complete with fibrous, waterproof slot sealer or removable foam slot filler.
2. Acceptable Manufacturers and Products:
   a. Gateway Beehive Slot.
   b. Heckman Building Products No. 100.

B. Continuous Concrete Inserts: 12 gauge minimum cold-formed galvanized or painted steel, “U” section to support 2000 pound minimum allowable point load.

1. Acceptable Manufacturers:
   a. Cooper B-Line
   b. Unistrut

C. Wedge Type Shelf Angle Inserts: Malleable iron castings with wedge shaped holding faces to receive 5/8 inch askew head bolt.

1. Do not use inserts complete with askew head bolts, flat washers, nuts and horseshoe shims.
2. Acceptable Manufacturers:
   a. Dayton Superior.
   b. Gateway Building Products.

D. Expansion Sleeves: Where reinforcing extends from concrete mass to support adjacent slab, with provisions for expansion required, provide metal sleeve at each bar to permit movement.
   1. Provide at stoops and elsewhere as indicated.

E. Reglets: Form reglets in concrete exposed to weather (for membranes, flashing and similar items), with removable forms (inserts). Form reglets, wedge-shaped to preserve sharp edges of concrete with twice material thickness, but not less than 3/8 inch.
   1. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.
   2. Do not use metal reglets, except where specifically approved.
   3. For concealed reglets use 24-gauge galvanized metal flashing reglet #307.
   4. Acceptable Manufacturers:
      a. Hohmann-Barnard.
      b. Gateway Building Products.
      c. Heckman Building Products.

F. Dowel Caps: Plastic material of size recommended for rod diameter.

G. Cast-Metal Stair Nosing: Cast iron with an integral abrasive, as-cast finish consisting of aluminum oxide, silicon carbide, or a combination of both.
   1. Fabricate units in lengths necessary to accurately fit openings or conditions.
   2. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.
   3. Apply bituminous paint to concealed surfaces of cast-metal units set into concrete.

H. Refer to Section 05 50 00 for embeds and other fabricated items for insertion into concrete.

2.5 CURING AND SEALING MATERIALS

A. Manufacturers: Subject to compliance with the requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, those listed below.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film, curing paper or white burlap-polyethylene sheet.

C. Water: Potable.

D. (CS-1) Clear, Non-residual, Waterborne, Membrane-Forming Curing Compound: Apply in accordance with manufacturer's recommendations and at coverage rate meeting ASTM C 309, Type 1, Class B, 18 to 22 percent solids. To be used at contractor's option in lieu of moist cure, in accordance with ACI 301, for floors to receive tile work, toppings, liquid applied waterproofing, synthetic flooring or other surface treatments for which bonding could be impaired by surface residue.
   1. L&M Cure R; L&M Construction Chemicals, Inc.
   2. 1100 Clear; W.R. Meadows.
   3. SpecRez; SpecChem, LLC
2.6 BEARING PADS

A. Non-Slip Plastic Bearing Pads: High-density plastic bearing pads with one rough surface for placement against hardened concrete and one smooth surface to be placed against adjacent bearing pad to create a slide bearing.
   1. Minimum pad thickness: 1/4 inch.
   2. Acceptable Manufacturers and Products:
      a. Con-Serv: Type CSB
      c. Dayton Superior: P-82 Bearing Strips

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install concrete accessories and related materials as specified in Section 03 11 00 - Concrete Forming, Section 03 20 00 - Concrete Reinforcing and Section 03 30 00 - Cast-in-Place Concrete.

END OF SECTION
SECTION 032000 - CONCRETE REINFORCING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Reinforcing bars for cast-in-place concrete.
   2. Smooth bar dowels for concrete slab joints.
   3. Welded steel wire fabric where noted in the drawings.
   4. Ties and supports for reinforcement.
   5. Fiber reinforcement where noted in the Drawings.

B. Related Sections:
   1. Section 031100 - Concrete Forming.
   2. Section 031500 - Concrete Accessories.
   3. Section 033000 - Cast-in-Place Concrete.

1.2 REFERENCES

B. ACI 315 - Standards on Details and Detailing of Concrete Reinforcement.
C. ACI 318 - Building Code Requirements for Structural Concrete.
D. AWS D1.4 - Structural Welding Code Reinforcing Steel.
F. CRSI - Placing Reinforcing Bars.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of manufactured material and product indicated

B. Shop Drawings:
   1. Shop Drawings: Submit in accordance with ACI 315, “Details and Detailing of Concrete Reinforcement”.
   2. Include placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing and hoop spacing.
   3. Show locations, type and quantities of bolsters, spacers, chairs, support bars and other accessories.
   4. Show concrete cover dimension from face of form to reinforcing bars.

1.4 INFORMATIONAL SUBMITTALS
A. Welding Certificates.

B. Material Certificates: For each of the following, signed by manufacturers:
   1. Steel reinforcement and accessories

1.5 LEED SUBMITTALS

A. Submit required product data and documentation in accordance with Section 01 81 13 - Sustainable Design Requirements and Section 01 33 00 - Submittal Procedures:
   1. Product Data for LEED MRc 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
      a. Include statement indicating costs for each product having recycled content.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Perform concrete reinforcing work in accordance with Concrete Reinforcing Steel Institute's recommended practices.

B. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM C1077 and ASTM E329 to conduct the testing indicated, as documented according to ASTM E548.
   1. Allow specified inspector to observe reinforcing steel in place prior to pouring of concrete for each section.
   2. Do not pour concrete until permission to proceed with placement of concrete has been granted by specified inspector.
   3. Notify specified inspector sufficiently in advance of scheduled time for pouring of concrete to allow observation to be made and corrections or adjustments completed, where required.

C. Welding: Qualify procedures and personnel according to AWS D1.4, "Structural Welding Code-Reinforcing Steel."

1.7 DELIVERY, STORAGE AND HANDLING

A. Materials shall be new, free of rust, loose scale or other coating that would reduce or destroy bond.

B. Deliver reinforcement bundled, tagged and marked. Tags to indicate bar size, lengths, and other information corresponding to markings shown on placement diagrams.

C. Deliver, store and handle reinforcement to prevent bending, damage and accumulation of dirt or excessive rust.

D. Avoid damaging coatings on steel reinforcement.
PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 50 percent.

B. Reinforcing Bars: ASTM A615, Grade 60, deformed.

C. Low-Alloy-Steel Reinforcing Bars: Reinforcing Steel to be Welded or Special Ductile Reinforcement: ASTM A706, Grade 60, deformed.

D. ASTM A706, Grade 80, deformed, where designated on Contract Documents.

E. Plain-Steel Welded Wire Reinforcement: ASTM A185 or ASTM A1064, fabricated from as-drawn plain-steel wire into flat sheets. Rolls are not permitted.

F. Deformed-Steel Wire and Deformed Bar Anchors: ASTM A496 or ASTM A1064.

2.2 REINFORCEMENT ACCESSORIES

A. Wire Bar Type Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture according to CRSI’s “Manual of Standard Practice”.

B. Supports: For slabs-on-grade with steel reinforcement use supports with sand plates, precast concrete chairs, or horizontal runners where base materials will not support chair legs.

C. Plastic-Tipped or Stainless Steel Legs: For concrete surfaces exposed to view or weather where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected or CRSI Class 2 stainless-steel bar supports. Hot dip galvanized support accessories may be used against formed surfaces not exposed to view or to weather.

D. Precast Concrete Chairs: Use over membrane waterproofing or underslab vapor retarder/barrier to prevent penetration of membrane or barrier.

E. Smooth Bar Dowels: ASTM A615, Grade 60, plain round bars. Cut bars true to length with ends square and free of burrs.

F. Mechanical Splice Systems: Mechanical connectors consisting of threaded type coupler forged from high quality steel meeting requirements of ACI 318 for mechanical splices.
   1. Use only where explicitly referenced on Drawings or as approved by Engineer.
   2. Mechanical Splice Systems shall have current ICC-ES report approval in accordance with ICC Acceptance Criteria AC133.
   3. All couplers shall be installed per the manufacturer’s approved procedures.
   4. Acceptable Manufacturers and Products:
      a. Lenton Couplers: Erico, IAPMO UES ER-0129.
2.3 FABRICATION

A. Fabricate steel reinforcement in accordance with ACI 315, CRSI’s “Manual of Standard Practice” and accepted shop drawings.

B. Do not re-bend or straighten steel reinforcement except where specifically accepted.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Underfloor Vapor Retarders/Barriers: When chairing reinforcement on top of underfloor vapor retarders, use only concrete brick type reinforcing bar supports, or provide 6 in x 6 in protective pads of asphaltic hardboard or other material recommended by the manufacturer. Do not displace or damage vapor retarder.

B. After installation of reinforcement but before pouring concrete, check for damage to underfloor vapor retarder/barrier. Repair any damage and reseal underfloor vapor retarder before placing concrete in accordance with Section 03 30 00.

C. Clean steel reinforcement to remove loose rust and mill scale, earth, ice and other foreign materials which will reduce or destroy bond with concrete.

D. Install concrete reinforcement in accordance with reviewed shop drawings and CRSI recommended practices.

E. Accurately position, support, and secure steel reinforcement against displacement by formwork, construction, or concrete placement operations.

F. Locate and support steel reinforcing by metal bolsters, spacers, chairs and hangers to maintain specified concrete cover. Securely tie bars and supports together with 16 gauge wire to hold steel reinforcement accurately in position during concrete placement operations. Set wire ties so that twisted ends are directed away from concrete surfaces.

G. Installing bars into wet concrete is prohibited.

H. Provide bar supports in sufficient number and heavy enough to carry steel they support. Place no bar more than 2 inches beyond last leg of continuous bar support. Do not use bar supports to support runways for concrete buggies, or similar loads.

I. Steel reinforcement partially embedded in concrete shall not be field bent, except as indicated or permitted by Structural Engineer.

J. For walls reinforced on both faces, provide spreader bars and chairs to surfaces of forms on each side at spacings not to exceed 8 feet in either direction. For walls with single layer of reinforcing, provide chairs each side at spacings not to exceed 8 feet in either direction.

K. Splice bars only where shown or noted. Comply with requirements of ACI 318 for minimum lap of bars and stagger, unless noted otherwise. Weld or mechanically couple splices in bars larger than #11, or where #11 bars are spliced to larger size bars. Comply with requirements of AWS D1.4 for welding of bars.
L. Install welded wire fabric in longest practicable lengths on bar supports spaced to minimize sagging. Offset end laps in adjacent sheets to prevent continuous laps in either direction. Lap edges and ends of adjoining sheets at least two mesh spacings. Lace overlaps with wire. Locate fabric as indicated on Drawings.

M. Install smooth bar dowels in concrete slab joints where shown. Center dowels on joint, positioned at center of slab depth and aligned perpendicular to face of joint both vertically and horizontally. Within 30 minutes of placement of adjacent concrete along doweled joints, apply thin uniform coating of liquid asphalt MC-250 or road tar RT-6 on free ends of dowels.

N. Exposed reinforcing steel after concrete has been placed, indicating steel is not properly located, will be sufficient cause for rejection, removal and replacement of concrete section.

O. Tack welding of reinforcing steel is prohibited. Reinforcement damaged by arc strikes or welding shall be replaced.

3.2 FIELD QUALITY CONTROL

A. Testing and Inspection: Owner will engage qualified special inspectors. On a periodic basis, inspect all reinforcing steel in all cast-in-place concrete, excluding slabs on grade, footings without transverse reinforcement, and topping slabs.
   1. Verify size and grade of reinforcing steel.
   2. Verify reinforcing bars are free of dirt, excessive rust and damage.
   3. Verify reinforcing bars are adequately tied, chaired and supported to prevent displacement during concrete placement.
   4. Verify proper clear distances between bars and to surfaces of concrete.
   5. Verify reinforcing bar size and placement.
   6. Verify bar laps for proper length and stagger and bar bends for minimum diameter, slope and length.
   7. Verify mechanical splices are placed in accordance with Contract Documents and reviewed shop drawings.
   8. Verify epoxy coating is present at locations noted on the Contract Documents, include tie wires, chairs, bolsters, etc. Verify coating damage is repaired in accordance with the Contract Documents.

B. Welding of Reinforcing Bars: On a continuous basis, visually inspect 100% of all reinforcing bar welds as the welding is performed, per AWS D1.4. Verify proper joint preparation is provided and proper electrodes are used and properly stored and dried.

END OF SECTION
SECTION 033000 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
2. Proportioning, mixing, conveying, placing, finishing, curing, and testing of cast-in-place concrete.
4. Coordinate installation of embedded items furnished and installed under other sections.

B. Related Requirements:
1. Section 031100 – Concrete Forming.
2. Section 031500 – Concrete Accessories; Underslab vapor barriers.
3. Section 032000 – Concrete Reinforcement.
4. Section 033543 – Polished Concrete.
5. Section 055000 – Metal Fabrications.
7. Section 310000 – Earthwork.

1.2 REFERENCES

A. ACI 117 - Specifications for Tolerances for Concrete Construction and Materials.
B. ACI 214 - Recommended Practice for Evaluation of Strength Test Results of Concrete.
C. ACI 301 - Specifications for Structural Concrete for Buildings.
D. ACI 304 - Guide for Measuring, Mixing, Transporting and Placing Concrete.
E. ACI 305 - Hot Weather Concreting.
F. ACI 306 - Cold Weather Concreting.
G. ACI 308 - Specifications for Curing Concrete.
H. ACI 309 - Guide for Consolidation of Concrete.
I. ACI 318 - Building Code Requirements for Structural Concrete.
J. ACI 1155
L. ASTM 1155 – Test Method for Determining FF and FL.
M. CBC 2016 – California Building Code including provisions applicable to DSA regulated facilities.

N. IAPMO Evaluation Service (IAPMO-ES):

O. ICC Evaluation Service (ICC-ES):

P. State of California, Department of Transportation (Caltrans):

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. LEED Submittals:
   1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.
   2. Product Data for Credit IEQ 4.3: For curing and sealing compounds, documentation including printed statement of VOC content.
   3. Design Mixtures for Credit ID 1.1: For each concrete mixture containing fly ash as a replacement for Portland cement or other Portland cement replacements, and for equivalent concrete mixtures that do not contain Portland cement replacements.

C. Submit mix design for each type and strength of concrete. Proportion designs in accordance with "Proportioning on the Basis of Field Experience and/or Trial Mixtures" of ACI 318.

D. Each mix design shall contain the following information:
   1. Mix number (which will correspond to mix ticket on trucks delivered to site) and location of concrete on project.
   2. Applicable mix specifications including:
      a. Design strength.
      b. Slump.
      c. Air content.
      d. Unit weight.
   3. Mix ingredients including quantities, ASTM designations, and sources for:
      a. Cementitious materials including fly ash, silica fume, and GGBFS.
b. Aggregates.
c. Water.
   1) Indicate amounts of mix water to be withheld for later addition at Project Site.
d. Admixtures (including manufacturer).

4. Test results:
   a. Compressive strength results of trial batches or historical test data.
   b. Statistical computations showing required average strength of mix.
   c. Aggregate property results for exterior horizontal concrete in accordance with Article 2.1.C of this Section.
   d. Unit weight.
   e. Slump.
   f. Water/cementitious ratio of mix.
   g. Air content.

5. Material Certificates: Signed by manufacturers certifying that materials comply with Project requirements.

6. Mix designs shall be signed and sealed by a Professional Engineer licensed in the State of California.

E. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

F. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.
   1. Proposed construction joint and saw cut contraction joints locations for slab on grade.
   2. Location of joints is subject to approval of the Architect/Engineer.

G. Slab Depression Layout: Indicate locations and depths of depressed slab for terrazzo, walk-off mats, and other architectural floor finishes.

1.5 INFORMATIONAL SUBMITTALS

A. Placing, Finishing, and Curing Procedures: Detailed description of methods, materials, and equipment used to comply with requirements.

B. Cold-Weather and Hot-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with requirements.

C. Flooring Coordination Plan (FCP): The General Contractor (GC) shall develop a Flooring Coordination Plan (FCP) prior to placement of any on-grade or elevated floor slabs. The GC shall conduct a pre-installation meeting to coordinate with all trades as it relates to the installation of the floor slab. The plan shall be signed by all trade representatives confirming agreement. Submittal is for information only and will not be approved or rejected. The FCP shall include the following items:
   1. Review ACI302.2 “Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring.”
   2. Concrete mix design.
   3. Discussion of delay of drying time due to re-wetting of floor slabs per on-site field conditions.
   4. Type and degree of concrete finish with respect to flooring adhesive and material.
5. Curing process.
6. Application of topical finishes such as slab curing compounds and sealers, if requested by the Contractor, with certificates of compatibility.
7. Moisture/pH testing procedure and frequency.
8. Trade representative work schedules.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Use plant mixed concrete mixed in stationary mixers.
   1. Truck mixed concrete is allowed provided procedures in ASTM C94 are followed and documented.
   2. Mix and deliver concrete in accordance with ASTM C94.
   3. Concrete plant shall have a current certificate from the National Ready Mix Concrete Association or another agency acceptable to DSA. The certification shall indicate that the plant has automatic batching and recording capabilities.

B. Installer Qualifications: Perform concrete work in accordance with ACI 318, unless specified otherwise. Installation work shall be supervised by a ACI-certified Flatwork Technician.

C. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM C1077 and ASTM E329 to conduct the testing indicated, as documented according to ASTM E548.

D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

E. Pre-Construction Conference: Conduct conference at Project site to comply with requirements of Section 01 45 33.
   1. Review special inspection and testing and inspecting agency procedures for field quality control, concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction contraction and isolation joints, and joint-filler strips, semirigid joint fillers, forms and form removal limitations, shoring and reshoring procedures, vapor-retarder installation, anchor rod and anchorage device installation tolerances, steel reinforcement installation, floor and slab flatness and levelness measurement, concrete repair procedures, and concrete protection, and curing application procedures.

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS

A. Cementitious materials and aggregates shall have a proven history of successful use together, or submit evidence satisfactory to Owner's Representative that aggregate will not react harmfully in presence of alkalis in cement.

B. Cementitious Materials. Combination of Portland cement and supplementary cementitious materials; subject to limitations specified herein.
   1. Portland cement: ASTM C150, Type I, II or V, low alkali.
2. Slag cement: ASTM C989, Grade 100 or 120. 30% replacement.

C. Coarse Aggregates:
   1. ASTM C33.
   2. Cleanliness value shall not be less than 75 when tested in accordance with California Test 227, "Evaluating Cleanliness of Coarse Aggregate".
   3. Aggregate shall contain no thin or elongated pieces. The length of any piece shall not exceed 2½ times the average thickness.
   4. Aggregate for Shrinkage Controlled Concrete shall be from one of the following sources, or approved equal: Sechelt (as supplied by Hanson), limestone (Hanson).
   5. Aggregate for Lightweight Concrete: ASTM C330, 3/8 inch size. As supplied by Hanson Sechelt sand and pumice aggregate, Trinity Expanded Concrete & Shale, or approved equal.

D. Fine Aggregates:
   1. ASTM C33.
   2. Sand equivalent shall not be less than 75 when tested in accordance with California Test 217, "Sand Equivalent".

E. Normal Weight Concrete Aggregates: (Excluding exterior horizontal concrete) ASTM C33, uniformly graded. Do not use aggregates containing soluble salts or other substances which can cause stains on exposed surfaces. Use aggregates from one source of supply corresponding to that on which selection of concrete proportions was based.

F. Aggregate Gradation: Conform to ASTM C33.

G. Mixer wash-out operations; subject to limitations specified herein.
   1. Provide 100% potable water for Architectural Concrete, Shrinkage Controlled Concrete, post-tensioned concrete, and lightweight concrete.
   2. Combined water for other uses may contain maximum 25% reclaimed water meeting requirements of ASTM C1602.

H. Water: ASTM C94. Fresh, clean, potable, free from injurious amounts of oils, acids, alkalies, salts, organic materials, or other substances that may be deleterious to concrete or steel.

2.2 ADMIXTURES

A. General: Admixtures shall be certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material and to be compatible with other admixtures and cementitious materials. Do not use admixtures containing calcium chloride or thiocyanates.

B. Manufacturers: Subject to compliance with the requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, those listed below.

C. Air-Entraining Admixtures (AEA): ASTM C260, max 6% on light weight.
   1. Euclid Chemical Company: Air-Mix.
   2. General Resource Technology: Polychem AE.
   3. Grace Construction Products: Daravair series or Darex series.
   4. BASF: MasterAir AE 90
5. Protex Industries: Protex AES.

D. Water Reducing Admixtures (WRA): ASTM C494, Type A.
   1. Euclid Chemical Company: Eucon WR-75.
   3. Grace Construction Products: WRDA.
   4. BASF: MasterPozzolith 210 or MasterPozzolith 322 N

E. Mid-Range Water-Reducing Admixtures (MRWRA): ASTM C494, Type A.
   1. Euclid Chemical Company: Eucon A+.
   4. BASF: MasterPolyheed 997 or MasterPolyheed FC100.

F. High-Range Water Reducing Admixture (HRWRA): ASTM C494, Type F or G.
   1. Euclid Chemical Company: Eucon 37 or Plastol 5000.
   3. Grace Construction Products: ADVA 100 or Daracem 100.
   4. BASF: MasterGlenium 3030 NS, 3030 NS, or 3200 HES.

G. Water Reducing and Retarding Admixture: ASTM C494, Type D.
   1. Euclid Chemical Company: Eucon Retarder-75.
   2. General Resource Technology: Polychem R.
   4. BASF: MasterPozzolith 80 or MasterPozzolith 200N.

H. Non-Corrosive, Non-Chloride Accelerator: ASTM C494, Type C or E.
   1. Euclid Chemical Company: Accelguard 80.
   4. BASF: MasterSet A 534.

I. Viscosity Modifying Admixture: ASTM C494, Type S.
   1. Euclid Chemical Company: Visctrol.
   2. General Resource Technology: Polychem VMA.
   4. BASF: MasterMatrix VMA 362.

J. Prohibited Admixtures: Calcium chloride, thiocyanates or admixtures effectively containing chloride ions (more than 0.05 percent) are not permitted. No accelerators without special permission.

2.3 BONDING COMPOUNDS

A. Bonding Compound: ASTM C1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene. Use to bond toppings to base slab.
2.4 REPAIR MATERIALS

A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch and that can be feathered at edges to match adjacent floor elevations.
   1. Cement Binder: ASTM C150, Portland cement or hydraulic or blended hydraulic cement as defined in ASTM C219.
   2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
   3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by underlayment manufacturer.
   4. Compressive Strength: Not less than 4100 psi at 28 days when tested according to ASTM C109/C109M.

B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch and that can be filled in over a scarified surface to match adjacent floor elevations
   1. Cement Binder: ASTM C150, Portland cement or hydraulic or blended hydraulic cement as defined in ASTM C219.
   2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
   3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by topping manufacturer.
   4. Compressive Strength: Not less than 5000 psi at 28 days when tested according to ASTM C109/C109M.

C. Polymer-Modified, Cementitious Patching Mortar: Packaged, dry mix for repair of concrete and that contains a non-redispersible latex additive as either a dry powder or a separate liquid that is added during mixing.
   1. Compressive Strength: Not less than 5000 psi at 28 days when tested according to ASTM C109/C109M.

2.5 CONCRETE MIXING

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 211.1 and ACI 301.

B. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C94, with exceptions specified herein, and ASTM C1116 where fibers are used, and furnish batch ticket information.
   1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

C. Admixtures: Use approved admixtures according to manufacturer's written instructions.
   1. Use chemical admixtures in concrete, as required, for placement, workability, durability, and controlled set time.
D. Air Content:
   1. Exterior exposed concrete shall contain 6 percent entrained air with maximum tolerance of plus or minus 1.5 percent.
   2. Lightweight concrete may contain 6 percent entrained air with maximum tolerance of plus or minus 1.5 percent.
   3. Do not allow air content of hard-troweled finished floors to exceed 3 percent.

E. Concrete Slump Limits: Measured according to ASTM C143 at point of placement.
   1. 4 inches without water reducing admixtures.
   2. 5 inches after addition of WRA or MRWRA.
   3. 7 inches after addition of HRWRA.
   4. A tolerance of up to one inch above indicated maximum will be allowed for one batch in any five consecutive batches tested.
   5. If the maximum water-cement ratio is not exceeded, concrete arriving at the jobsite within 60 minutes of the initial batching that has a slump less than the maximum allowed may have water added when accepted by the project inspector.
   6. Water reducing admixtures may be added to increase the slump when water cannot be added and additional slump is necessary for workability when accepted by the project inspector.
   7. Truck batch tickets shall clearly indicate maximum water permissible for adding at jobsite without exceeding the specified maximum water-cementitious materials ratio.
   8. Water shall not be added to the mix after any supplemental water reducing admixtures have been dosed into the mixer.
   9. Water shall not be added to mix after samples are taken from batches randomly selected for testing.

2.6 SOURCE QUALITY CONTROL

A. Batch Plant Inspection:
   1. An approved special inspector from the Owner’s Testing Agency shall review mix proportions with the licensed weighmaster at the start of each day’s placement and observe the first batching.
   2. Licensed weighmaster to positively identify materials as to quantity and certify to each load by ticket.
   3. Tickets shall be transmitted to the inspector of record by a truck driver with load identified thereon. The inspector will not accept the load without a load ticket identifying the mix and will keep a daily record of placements, identifying each truck, its load and time of receipt and approximate location of deposit in the structure and will transmit a copy of the daily record to the enforcement agency.
   4. At the end of the project, weighmaster shall furnish an affidavit to the enforcement agency certifying that concrete furnished conforms in every particular to proportions established by mix designs.
   5. Batch ticket must be legible.

2.7 CONCRETE MIXTURES FOR BUILDING ELEMENTS

A. 70% Portland, 30% slag.

B. Mix “A1”: High SCM mix for grade beams.
   1. Comply with all requirements for mix “A” except that compressive strength is 6,000 psi.
C. Mix “B”: For slab-on-ground, curbs and ground level equipment pads, stair pan fills.
1. Compressive strength: 4,000 psi at 28 days (ASTM C39).
2. Slump: 6 inches, plus or minus 1-inch tolerance (ASTM C143).
3. Cementitious material: Total cementitious material shall not be less than 550 lbs per cubic yard.
5. Coarse aggregate shall be from specified source for Shrinkage Controlled Concrete. Do not blend pea gravel with shrinkage controlled aggregates.
6. Admixtures: Mid-range, water-reducing admixture at necessary dosage to provide adequate slump and workability at specified water content.
7. Limit total water to 275 lbs maximum.
8. Limit water-to-cementitious material ratio to 0.45 by weight.

D. Mix "E": For lightweight structural concrete fill over steel deck, equipment pads and curbs over lightweight concrete fill over metal deck, exterior supported structural slab where noted on plans.
1. Compressive strength: 4,000 psi at 28 days (ASTM C39).
2. Slump: 4 inches, plus or minus 1-inch tolerance (ASTM C143), measured at point of placement. Slump, measured at truck, shall not exceed 7 inches and slump loss due to pumping shall not exceed 2 inches.
3. Equilibrium density: 113 lbs per cu ft, plus or minus 3 pcf (ASTM C567, quick method). Fresh density, measured at truck, shall not exceed 125 lbs per cu ft. (ASTM C138).
4. Air: 5.5%, plus or minus 1.5% tolerance, air by volume at point of placement (ASTM C173 - Volumetric Method).
5. Cementitious material: 70% Portland, 30% slag.
6. Aggregate: Mix shall contain a minimum of 1000 pounds of fully presaturated lightweight coarse aggregate per cubic yard (based on use of Trinity’s Frazier Park expanded clay aggregate).
7. Admixtures:
8. ASTM C494, Type A/F mid-range, water-reducing admixture at manufacturer's recommended mid-range dosage.
9. Provide VMA at manufacturer’s recommended dosage where required to facilitate pumping.

E. Mix F: For mud slab.
1. Compressive strength: 1,500 psi at 7 days (ASTM C39).
2. Slump: 4 inches (ASTM C143), plus or minus 1-inch tolerance.
3. Aggregate size: Size 7 (1/2 inch) coarse aggregate.
4. Fiber reinforcing: Add synthetic macro-fibers at a dosage of 5 lbs per cu yd.

F. Watertight Concrete: For sumps, pits and where otherwise designated.
1. Same as Mix "B", except as otherwise noted.
2. Admixtures: Add crystalline waterproofing admixture at manufacturer’s recommended dosage rate.

G. Patching Mortar: One part Portland cement to two parts sand. At exposed surfaces, substitute white cement as necessary to match color of surrounding concrete.
1. Intended for use for patching of form ties and bug holes. Not suitable for repair of large defects; provide pre-packaged repair mortar suitable for size and shape of defect and approved by Owner's Representative.
H. Polished Concrete: Refer to Section 033543 for additional mix requirements, aggregates, and finishing, grinding and polishing for normal- and light-weight concrete mixes indicated to have polishing.

PART 3 - EXECUTION

3.1 INSTALLATION OF UNDERFLOOR VAPOR BARRIERS

A. Install vapor barrier (UVB-3) directly below all new interior slabs.
   1. Place vapor barrier over underfloor material specified in Division 31.
   2. Do not cover vapor barrier with sand or aggregate.
   3. Pour concrete slab directly over vapor barrier.

B. Examine substrates and conditions, with Installer present, for compliance with requirements for Sections in which substrates and related work are specified and other conditions affecting performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

D. Verify that sleeves, ties, and other penetrating components which pass through surfaces to receive barrier are rigidly installed.

E. Clean substrates of substances harmful to vapor barriers, including removing projections capable of puncturing vapor barriers.

F. Place, protect, and repair vapor barrier sheets in accordance with manufacturer’s instructions and ASTM E1643.
   1. Unroll vapor barrier with the longest dimension parallel with the direction of the pour.
   2. Lap vapor barrier over footings and seal to foundation walls.
   3. Overlap joints 6 inches and seal with pressure sensitive tape.
   4. Seal penetrations including pipes, conduits, and ducts with pipe boots and pressure sensitive tape.
   5. No penetration of the vapor barrier is allowed except for reinforcing steel and permanent utilities.
   6. Terminate vapor barrier at walls with sealant.
   7. Repair damaged areas by cutting patches of vapor barrier, overlapping damaged area 6 inches and taping all four sides with pressure sensitive tape.

3.2 PLACING CONCRETE

A. Place concrete in accordance with ACI 301. Consolidate concrete in accordance with ACI 309 using high frequency vibrators.

B. Clean forms, reinforcing and accessories and dampen forms immediately prior to placing concrete.

C. Schedule concrete deliveries to ensure that concrete in each load is placed within 90 minutes after mixing water is added.
D. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

E. Deposit concrete as near as practicable to its final position to avoid segregation due to rehandling or flowing, in layers not exceeding 18 inch in depth. Deposit concrete continuously or in layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness.
   1. Consolidate placed concrete with mechanical vibrating equipment. Use equipment and procedures for consolidating concrete recommended by ACI 309R.
   2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations no farther than the visible effectiveness of the vibrator. Place vibrators to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mix constituents to segregate.
   3. Do not insert vibrators to bottom of slabs-on-grade with underfloor vapor barriers to avoid damaging this membrane.

F. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
   1. Consolidate concrete during placement operations so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
   3. Screed slab surfaces with a straightedge and strike off to correct elevations.
   4. Slope surfaces uniformly to drains where required.
   5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, free of humps or hollows, before excess moisture or bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

G. Do not allow concrete to fall freely more than 5 feet. Use tremies, chutes or elephant trunks where necessary.

H. Do not use concrete that has partially hardened or been contaminated by foreign materials, nor concrete that has been retempered or remixed after initial set.

I. Before depositing new concrete on or against concrete that has set at construction joints, clean, wet and apply neat cement slurry to existing surfaces. Tighten forms prior to resuming pouring.

J. Exercise care to prevent splashing of forms or reinforcing with concrete above level of concrete being placed.

K. Clean reinforcement projecting above or out of concrete immediately after completion of particular unit of pour.

L. Do not place concrete under adverse weather conditions unless adequate protection is provided. Refer to ACI 301, for weather restrictions and placing temperatures.

M. ITL shall monitor vibrations during pile driving or other significant sources of vibration to determine minimum distance to be maintained from concreting operations to avoid damage to freshly placed concrete.
N. Comply with ACI 301 for installation of concrete topping mixtures.

3.3 CONSTRUCTION, CONTRACTION AND EXPANSION JOINTS

A. Provide construction joints when stoppage of concreting operations occurs.

B. Continue reinforcing steel across construction joints unless noted or detailed otherwise.

C. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect/Engineer.
   1. Unless detailed otherwise, locate horizontal construction joints in walls and columns at underside of floor slabs and beams.

D. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Where contraction joint spacings are not specifically shown they shall be spaced approximately 15 feet on centers at interior locations where joints will be exposed or under non-resilient floor covering. At interior locations below resilient finish or carpet spacings may be increased to approximately 20 feet. Interior panels shall be near-square with short: long side ratio not less than 2:3. At exterior locations spacings of contraction joints shall not exceed 10 feet on centers and short-long side ratio shall not be less than 3:4. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness, as follows:
   1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Sawcut joints in concrete slabs-on-grade as soon as the slab will support the weight of the saw and operator without disturbing the final finish. Sawcutting can normally occur from 0 to 2 hours after final finishing. Cut 1/8 inch wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.
   2. Provide very lightly rounded edges at construction, control and expansion joints where slab joint will be exposed.
   3. Where sawcut control joints in exterior slabs-on-grade are shown, provide in accordance with ACI 301, 1/4 depth of slabs unless shown otherwise. Cut joints to their full depth as soon as condition of concrete will permit, in 2 or more passes, with first pass cut 1/2 inch deep.

E. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
   1. Terminate full-width joint-filler strips not less than 1/2 inch nor more than 1 inch below finished concrete surface where joint sealants, specified in Section 07 90 00 - Joint Protection, are indicated.
   2. Install joint-filler strips in lengths as long as practicable. Where more than 1 length is required, lace or clip sections together.

F. Provide vertical construction, control, and expansion joints in walls as detailed. Pour sections alternately with minimum waiting period of 48 hours between adjacent pours. Unless noted otherwise, locate joints midway between columns. Do not locate joints within 5 feet of corner, wall intersection or column. Unless noted otherwise locate vertical contraction joints in walls at 30 feet maximum spacing.

G. Special Roughened Construction Joints (SRCJ): For construction joints noted in the drawings as special roughed construction joints, in addition to keying, hardened concrete joint face shall
be cleaned totally free from laitance by bush hammering or sandblasting to provide rough, sound surface with roughness amplitude not less than 1/4 inch between projecting aggregate faces and recessed sand-cement matrix.

H. Install waterstops in concrete joints where noted in accordance with Section 03 11 00.

3.4 FINISHING FLOORS AND SLABS

A. Finish bare concrete floors (adjacent to floors with other surfacing) so concrete surface is level with other finishes, unless otherwise noted.

B. At areas to receive floor covering, grind smooth joints between slabs on grade and structural slabs and between existing and new surfaces to eliminate unevenness and to provide smooth, level surface across joints. Finish with plastic blades.

C. Wetting the concrete surface during finishing operations is prohibited.

D. Power floating with troweling machines equipped with normal trowel blades is prohibited.

E. Use caution when finishing lightweight concrete slabs to maintain trowel blades at shallow angle as possible during final finishing operations.
   1. Do not provide a hard steel trowel finish to lightweight concrete slabs or SOG.

F. Protect finished surfaces from damage. Keep free of abrasive materials.

G. In areas where water will be present (interior and exterior) place and finish slabs so areas will drain and water will not stand in puddles. Conform to slopes shown. At structural slabs, verify elevations of drains to ensure drains will be at low points. Where elevations and slopes are not indicated, generally slope floors 1/8 inch per foot uniformly to drains, unless otherwise directed by Architect.

H. Finish and measure surface so gap at any point between concrete surface and an unleveled, freestanding, 10-foot-long straightedge resting on 2 high spots and placed anywhere on the surface does not exceed 1/8-inch.

I. Apply slab finish to Floor Profile Number tolerances listed unless specifically noted otherwise on Drawings, according to ASTM E1155 “Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers” for randomly trafficked floor surfaces.
   1. Refer to ACI 302, Chapter 8 and Table 8.15.3, for recommended typical procedures to attain specified Floor Profile Numbers.

J. General Finishing Requirements: Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces as appropriate to attain slab finish specified.
   1. Utilize wet-screed guides, dry-screed guides, and/or edge forms for initial strikeoff set with optical or laser instruments as appropriate to attain specified Floor Profile Number. Check elevation after initial strikeoff and repeat as necessary.
   2. Smooth and restraighten surface using 8 to 10 foot wide bull float, darby, or modified highway straightedge.
a. Apply in two directions at 45 degree angle to strip for Overall Floor Flatness, FF30 or greater.

3. Wait until bleed water sheen has disappeared and concrete can sustain finishing operations without digging in or disrupting the levelness of the surface.

4. Float surface with one or more passes using a power float (float shoe blades or pans) or by hand floating if area is small or inaccessible to power driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture.

5. Uniformly slope surfaces to drains.

K. (CONC FIN-1) Hard Trowel Finish:

1. Follow General Finishing Requirements for initial procedures.
2. Restraighten surface if required following paste-generating float passes using 10-foot wide highway straightedge. Apply in two directions at 45 degree angle to strip. Use supplementary material to fill low spots.
3. Consolidate concrete surface, uniform in texture and appearance, with three or more passes using power trowel. Hand trowel areas inaccessible by power trowel.
4. Grind smooth any surface defects that would telegraph through applied floor covering system.

L. (CONC FIN-2) Non-Slip Broom Finish:

1. Follow General Finishing Requirements for initial procedures.
2. While still plastic, slightly roughen concrete surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with Architect before application.

M. (CONC FIN-3) Non-Slip Abrasive Finish:

1. Apply at rates recommended by the manufacturer, but not less than 25 pounds per 100 square feet.
2. Verify all procedures noted below are in compliance with manufacturer’s written instructions. Notify Architect of any discrepancies requiring resolution.
3. Follow General Finishing Requirements, steps 1 through 3, for initial procedures.
4. Break the surface using a power trowel with float shoes or attached pan.
5. Evenly distribute approximately two-thirds of the specified amount of non-slip aggregate with mechanical spreader.
6. After applied material has absorbed moisture, float surface using hand wooden floats. Take care not to tear through into the underlying concrete.
7. Apply remaining one-third of dry-shake hardener. Tamper aggregate flush with surface, but do not force below surface. Float surface in a like manner.
8. If needed, trowel until the desired surface finish is achieved.
9. After curing, lightly work surface with a steel wire brush or an abrasive stone and water to expose slip-resistive aggregate.

N. (CONC FIN-4) Light Trowel Finish:

1. Follow General Finishing Requirements for initial procedures.
2. Restraighten surface if required following paste-generating float passes using 10-foot wide highway straightedge. Apply in two directions at 45 degree angle to strip. Use supplementary material to fill low spots.
3. Consolidate concrete surface, uniform in texture and appearance, with one to three passes using power trowel. Hand trowel areas inaccessible by power trowel.
4. After final trowel, concrete finish shall have a light texture. Avoid burnished finish. Coordinate finish with flooring subsurface requirements.
5. Grind smooth any surface defects that would telegraph through applied floor covering system.

O. (CONC FIN–5) Trowel and Fine Broom Finish:
1. Follow General Finishing Requirements for initial procedures.
2. Consolidate concrete surface, with one pass using a power trowel.
3. Slightly scarify surface with soft bristled broom while concrete is still plastic.

P. (CONC FIN-6) Float Finish:
1. Follow General Finishing Requirements for initial procedures.

Q. (CONC FIN-9) Mineral Dry-Shake Floor Hardener Finish:
1. Apply at a rate of 1 to 1½ pounds per square foot, unless greater amount is recommended by manufacturer.
2. Concrete containing calcium chloride or more than 0.05% chloride ions by weight of cementitious materials are not permitted for metallic dry-shake hardeners.
3. Air content must be below 3% for all dry-shakes.
4. Verify all procedures noted below are in compliance with manufacturer’s written instructions. Notify Architect of any discrepancies requiring resolution.
5. Follow General Finishing Requirements, steps 1 and 2, for initial procedures.
6. Open the surface to promote movement of bleed water to the top by using a wooden bull float.
7. Wait until the concrete sets up sufficiently to support the weight of a power trowel.
8. Break the surface using a power trowel with float shoes or attached pan.
9. Evenly distribute approximately two-thirds of the specified amount of dry-shake hardener with mechanical spreader.
10. After applied material has darkened slightly to a uniform color from absorbed moisture, restraighten surface if required using 10-foot wide highway straightedge. Apply in two directions at 45 degree angle to strip.
11. Float surface using a power float (float shoe blades or pans) and/or hand wooden floats taking working moisture from the underlying concrete completely through the hardener. Take care not to tear through into the underlying concrete.
12. Apply remaining one-third of dry-shake hardener and continue floating in a like manner.
13. Consolidate concrete surface, uniform in texture and appearance, using power trowel. Hand trowel areas inaccessible by power trowel. Care shall be taken not to trowel-burn the surface.

R. (CONC FIN-10) Broom Finish:
1. Surfaces of concrete mixes with silica fume and/or calcium nitrite must be kept moist (not wet) during finishing operations to promote proper texturing. Pressure foggers with a reach capable of covering the entire surface can aid finishing operations.
2. Follow General Finishing Requirements, steps 1 through 3, for initial procedures.
3. Scarify surface with a transverse scored texture using a medium bristled broom perpendicular to main traffic route. Texture shall be as accepted by the Architect from sample panels.
4. Finish Tolerance: Surface shall not vary by more than ±1/2 inch anywhere from elevation noted on Drawings.
5. Fabricate 2 acceptable test panels simulating finishing techniques and final appearance. Intent of test panels is to simulate both high and low workability mixes, with slumps at time of casting to be 6 inches and 3 inches, respectively. Test panels shall be minimum
of 20 feet by 30 feet and use approved mix designs. Accepted test panels may be incorporated into the finished construction.

6. Finish all concrete slabs to proper elevations to ensure that all surface moisture will drain freely, and that no puddles exist. Contractor must bear cost of any corrections to provide positive drainage and repairing poorly finished surface areas.

S. (CONC FIN-11) Scratch Finish:
1. Follow General Finishing Requirements for initial procedures.
2. While still plastic, scarify slab surface to 1/8-inch amplitude with transverse scored texture by drawing broom, stiff brush, or rake across surface.

T. Coordinate final slab texture requirements with Division 9 flooring installer for proper adhesion of final flooring materials.

U. Summary Slab Finish Schedule:

<table>
<thead>
<tr>
<th>SLAB USE</th>
<th>SLAB FINISH</th>
<th>OVERALL Fr/F₄</th>
<th>LOCAL Fr/F₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed to view with light foot traffic, equipment pads, or to receive Penetrating Liquid Densifier and Sealer or other thin film-finish coating system</td>
<td>CONC FIN-1 Hard Trowel Finish</td>
<td>Fr30/F₄25</td>
<td>Fr24/F₄15</td>
</tr>
<tr>
<td>Egress stair exposed concrete treads and landings; exterior ramps, stairs and stoops; where shown on Drawings</td>
<td>CONC FIN-2 Non-Slip Broom Finish</td>
<td>Fr25/F₄20</td>
<td>Fr17/F₄15</td>
</tr>
<tr>
<td>Where shown on Drawings</td>
<td>CONC FIN-3 Non-Slip Abrasive Finish</td>
<td>Fr25/F₄20</td>
<td>Fr17/F₄15</td>
</tr>
<tr>
<td>Carpet; raised access floor; or base slabs below acoustic concrete topping slabs</td>
<td>CONC FIN-4 Light Trowel Finish</td>
<td>Fr25/F₄20</td>
<td>Fr17/F₄15</td>
</tr>
<tr>
<td>Thin set resilient flooring</td>
<td>CONC FIN-4 Light Trowel Finish</td>
<td>Fr30/F₄25</td>
<td>Fr24/F₄15</td>
</tr>
<tr>
<td>Thin set ceramic or quarry tile; stone flooring; epoxy terrazzo</td>
<td>CONC FIN-5 Trowel and Fine Broom Finish</td>
<td>Fr20/F₄15</td>
<td>Fr15/F₄10</td>
</tr>
<tr>
<td>Fluid-applied or sheet waterproofing; built-up or membrane; sand-bed terrazzo</td>
<td>CONC FIN-6 Float Finish</td>
<td>Fr20/F₄15</td>
<td>Fr15/F₄10</td>
</tr>
<tr>
<td>Loading dock and warehouse areas; where indicated on Drawings</td>
<td>CONC FIN-9 Dry-Shake Floor Hardener Finish</td>
<td>Fr35/F₄25</td>
<td>Fr24/F₄15</td>
</tr>
<tr>
<td>Parking ramps; exterior concrete pavement</td>
<td>CONC FIN-10 Broom Finish</td>
<td>Fr20/F₄15</td>
<td>Fr15/F₄10</td>
</tr>
<tr>
<td>Below bonded concrete floor topping or mortar setting beds for tile, portland cement terrazzo, and other bonded</td>
<td>CONC FIN-11 Scratch Finish</td>
<td>Fr20/F₄15</td>
<td>Fr15/F₄10</td>
</tr>
</tbody>
</table>
V. Measure Floor Profile Numbers within 72 hours of final finishing operations and prior to removal of forms on elevated slabs for each slab placement.
   1. Report deficient areas to Architect to determine repair procedures appropriate for final required finish.
   2. Make appropriate adjustments to construction procedures prior to next slab placement when previous slab placement is deficient.

3.5 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defective areas repaired and patched. Remove fins and other projections exceeding ACI 347R limits for class of surface specified.
   1. Apply to formed concrete surfaces unless indicated otherwise.

B. (CONC FIN-20) Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defective areas. Remove fins and other projections exceeding 1/8 inch amplitude.
   1. Apply to concrete surfaces exposed to public view or to be covered with a coating or covering material applied directly to concrete, such as waterproofing, dampproofing, veneer plaster, or painting.
   2. Do not apply rubbed finish to smooth-formed finish.

C. Rubbed Finish: Apply the following to smooth-formed finished concrete:
   1. (CONC FIN-21) Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
   2. (CONC FIN-22) Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix 1 part Portland cement to 1½ parts fine sand with a 1:1 mixture of bonding admixture and water. Add white Portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
   3. (CONC FIN-23) Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix 1 part Portland cement and 1 part fine sand with a 1:1 mixture of bonding agent and water. Add white Portland cement in amounts determined by trial patches so color of dry grout will match adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent

<table>
<thead>
<tr>
<th>SLAB USE</th>
<th>SLAB FINISH</th>
<th>OVERALL Fr/F_L</th>
<th>LOCAL Fr/F_L</th>
</tr>
</thead>
<tbody>
<tr>
<td>applied cementitious finish flooring material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polishing</td>
<td>Refer to Section 033543</td>
<td>Fr45/ F.30</td>
<td>Fr 30/F.20</td>
</tr>
</tbody>
</table>
formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

3.6 MISCELLANEOUS CONCRETE ITEMS

A. Provide miscellaneous concrete items as noted and detailed on Drawings.

B. Provide and install reinforcing, anchors and bolts in concrete where directed and required.

C. Provide for installation of inserts, hangers, metal ties and other fastening devices required for attachment of other work.

D. Properly locate fastening devices in cooperation with other trades and secure in position before concrete is placed.

3.7 CONCRETE CURING AND PROTECTION

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Provide curing and protection immediately after placement in accordance with ACI 301 using materials as specified in Section 03 15 00.

B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if the air temperature exceeds 80 degrees F, the wind speed exceeds 10 mph, or the relative humidity is less than 40 percent. Apply according to manufacturer’s written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms are removed during curing period, immediately employ one of curing materials or methods specified for concrete surfaces not covered by forms and continue for remainder of curing period.

D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces, by one or a combination of the following methods. Follow ACI 308 and ASTM 309.

1. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer’s written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

   a. Cure concrete surfaces to receive floor coverings with either a curing compound or moisture-retaining cover that the manufacturer recommends for use with floor coverings. Any deleterious residual material that might affect performance of floor covering shall be cleaned from surface prior to placement of floor covering. Polish Mirrorcrete applied by manufacturer for polish areas, Varar Seal 309 for areas with moisture sensitive floors applied by manufacturer. Curing compound must warrant to meet all floor curing requirements for moisture and PH.

E. Moisture Condition of Slabs – Following placement of concrete and climatization of building, check to see that any specified tests for moisture emission have been made and a written report submitted prior to floor covering or coating installation.
3.8 CONCRETE SURFACE REPAIRS

A. Defective Concrete: Repair and patch defective areas as determined by Architect/Engineer. Remove and replace concrete that cannot be repaired and patched to Architect’s approval and in accordance with ACI 301. Repair methods for defects affecting the concrete’s structural performance shall be closely coordinated between Contractor and Structural Engineer of Record.

B. Patching Material: Submit proposed patching materials for review and approval.

C. Preparation for Concrete Repairs:
   1. Provide shoring/bracing when concrete removal will remove supporting structure or weaken structure.
   2. Locate reinforcing steel in repair area using non-destructive testing. Do not damage or cut any reinforcing steel during the repair process.

D. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, delaminations honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.
   1. After form removal, remove honeycombs, rock pockets, and voids more than 1/2 inch in any dimension in solid concrete but not less than 1 inch in depth.
   2. Remove concrete within repair boundary in a manner that will not damage reinforcing steel or adjacent sound concrete materials.
   3. Saw-cut or grind perimeter of areas indicated for removal to a depth of at least 3/4 inch. Do not overcut.
   4. Remove additional concrete if necessary to provide a depth of removal of at least 1/2 inch or as required by patching material manufacturer over entire removal area. Avoid significant and sudden changes in depth of concrete removal.
   5. Where half or more of the perimeter of reinforcing bar is exposed, bond between reinforcing bar and surrounding concrete is broken, or reinforcing bar is corroded, remove concrete from entire perimeter of bar and provide at least a 3/4-inch clearance around bar.
   6. The resulting shape shall be as simple as is practicable with a minimum number of corners and acute angles.
   7. Remove layer of concrete weakened by interconnected microcracks caused by concrete removal with high-pressure water cleaning (5,000 to 10,000 psi) as described in SSPC-SP 12 or abrasive blasting as described in SSPC-SP 13.
   8. Thoroughly clean removal areas of loose concrete, dust, and debris
   9. Dampen repair area and surrounding concrete 6 inches beyond repair area and then remove standing water. Maintain substrate in a saturated surface dry condition.
   10. Apply mortar scrub coat with a brush, scrubbing it into surface and thoroughly coating repair area. If scrub coat dries, recoat before placing patching mortar.
   11. Allow surfaces of lifts that are to remain exposed to become firm and then finish to match and blend with adjacent concrete.
   12. Moist cure for at least 7 days or as recommended by the repair material manufacturer. Use of curing compounds is prohibited.

E. Repair defects on surfaces exposed to view by blending white Portland cement and standard Portland cement so that, when dry, patching material will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
F. Repair defects and fill tie holes on concealed formed surfaces that affect concrete's durability and structural performance as determined by Structural Engineer of Record.

G. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.

2. After concrete has cured at least 14 days, correct high areas by grinding.

3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching material. Finish repaired areas to blend into adjacent concrete.

4. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.

5. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete. Remove concrete within repair boundary in a manner that will not damage reinforcing steel or adjacent sound concrete materials.

   a. Saw-cut or grind perimeter of areas indicated for removal to a depth of at least 3/4 inch. Do not overcut.
   b. Remove additional concrete if necessary to provide a depth of removal of at least 1/2 inch or as required by patching material manufacturer over entire removal area. Avoid significant and sudden changes in depth of concrete removal.
   c. Where half or more of the perimeter of reinforcing bar is exposed, bond between reinforcing bar and surrounding concrete is broken, or reinforcing bar is corroded, remove concrete from entire perimeter of bar and provide at least a 3/4-inch clearance around bar.
   d. The resulting shape shall be as simple as is practicable with a minimum number of corners and acute angles.
   e. Remove layer of concrete weakened by interconnected microcracks caused by concrete removal with high-pressure water cleaning (5,000 to 10,000 psi) as described in SSPC SP 12 or abrasive blasting as described in SSPC-SP 13.
   f. Thoroughly clean removal areas of loose concrete, dust, and debris.
   g. Dampen repair area and surrounding concrete 6 inches beyond repair area and then remove standing water. Maintain substrate in a saturated surface dry condition.
   h. Apply mortar scrub coat with a brush, scrubbing it into surface and thoroughly coating repair area. If scrub coat dries, recoat before placing patching mortar.
   i. Place patching concrete by troweling toward edges of patch to force intimate contact with edge surfaces. For large patches, fill edges first and then work toward center, always troweling toward edges of patch.
   j. Moist cure for at least 7 days or as recommended by the repair material manufacturer. Use of curing compounds is prohibited.

6. Repair random cracks and single holes 1 inch or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place
patching material before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

H. Repair materials and installation not specified above may be used, subject to approval by the Architect/Engineer.

3.9 FIELD QUALITY CONTROL

A. Testing and Inspection: Owner will engage qualified special inspectors in accordance with Section 01 45 33.

1. Qualifications: The minimum category of special inspector required to perform services outlined below are noted by qualifications in parentheses. The definitions of the categories of special inspector are included in Section 01 45 33.

2. Certifications: Testing Agency shall have CCRL certification of the National Bureau of Standards.

B. Additional testing and inspecting, at Contractor’s expense, will be performed to determine compliance of corrected work with specified requirements.

C. On a periodic basis, perform concrete mix verification. (Technical I)

1. Verify mixer truck trip ticket conforms to approved mix design.
2. Verify that total water added to mix on site does not exceed that allowed by concrete mix design.
3. Verify that concrete quality is indicative of adequate mixing time, consistency and relevant time limits.

D. Sample and test all cast-in-place concrete. (Technical I)

1. Make, cure and determine strength of concrete test cylinders cast in field. Perform in accordance with ASTM C172 - Practice for Sampling Freshly Mixed Concrete, ASTM C31 - Practice for Making and Curing Concrete Test Specimens in the Field and ASTM C39 - Test Method for Compressive Strength of Cylindrical Concrete Specimens. Evaluation and acceptance of concrete shall be in accordance with ACI 318 with following exceptions:

   a. Make one set of cylinders for each day's operation and each class of concrete placed each day and shall be taken not less than once a day, or not less than once for each 50 cubic yards of concrete, or not less than once for each 2,000 square feet of surface area for slabs or walls. Additional samples for seven-day compressive strength tests shall be taken for each class of concrete at the beginning of the concrete work or whenever the mix or aggregate is changed.

      1) Test sets shall consist of 4 cylinders with fourth cylinder to be field-cured specimen.

      2) For slabs placed when temperatures are expected to fall below 32 degrees F within 72 hours of placement, cast-in-place (pop out) cylinders shall be used.

      3) These cylinders shall be placed close to corners and perimeter of pour.

   b. Store field-cured cylinder as near as possible to location of concrete represented by sample and give cylinder, insofar as practicable, same protection and curing as adjacent concrete.
1) Keep other 3 cylinders covered with plastic or wet burlap and in
60 - 80 degrees F temperature range for 24 hours, allowing no injury to
cylinders.
2) After this period, and prior to age of 48 hours, deliver 3 cylinders to
laboratory for additional curing, taking care not to freeze, crack or damage
specimens.

c. Deliver field-cured cylinder to laboratory at 28 days of age for testing to check
adequacy of curing and protection as described in ACI 318.
d. Test other 3 cylinders, laboratory cured, as follows: One at 7 days of age for
projecting probable 28 day strength and 2 cylinders at 28 days for acceptance of
average strength as described in ACI 318.
e. If additional field cured specimens are required to verify early strength of concrete,
contractor must pay for additional testing.

2. Determine slump of concrete in accordance with ASTM C143 - Test Method for Slump of
Hydraulic Cement Concrete. Perform one test for each set of test cylinders.
3. Determine air content of fresh concrete, when air content is specified, in accordance with
ASTM C173 or ASTM C231. Where placement is by pump, air content shall be measured
at location of placement. Perform one test for each set of test cylinders. Concrete used in
performing air content test shall not be used in fabricating test specimens.
4. Make, transport, and cure specimens as required to determine unit weight of structural
lightweight concrete in accordance with ASTM C567 - Test Method for Unit Weight of
Structural Lightweight Concrete. Perform one test for each day's operation where less
than 50 cubic yards is placed, plus additional set for each 100 cubic yards (or fraction
thereof) over and above first 50 cubic yards.
5. Test concrete temperature hourly when air temperature is 40 degrees F and below and
when 80 degrees F and above, and each time a set of test cylinders is made.
6. Mark each test cylinder with job name, Contractor's name, mix number, date, location of
pour and measured slump. In addition, mark measured air content when air-entraining
admixture is specified.
7. Submit copies of test results to Owner, Architect and Contractor as soon as practicable
after they are made.

E. On a continuous basis, inspect preparation and placement of all concrete, excluding strip
footings without transverse reinforcement. (Technical I)
1. Verify acceptable general condition of concrete base prior to placement.
2. Verify that concrete conveyance and depositing avoids segregation and contamination.
3. Verify that concrete is properly consolidated.
4. Verify reinforcement remains at proper location.
5. Verify underfloor vapor barrier/retarder is properly installed and not damaged during
concrete placement.

F. On a periodic basis, observe protection and curing methods for all concrete, excluding strip
footings without transverse reinforcement. (Technical II)
1. Verify specified curing procedures are followed.
2. Verify that specified hot and cold weather procedures are followed.

G. On a continuous basis, inspect all embedded anchors installed in concrete. (Technical II)
1. Verify specified size, type, spacing, configuration, embedment and quantity.
2. Verify proper concrete placement and consolidation around all embedded anchors.
3.10 EVALUATION OF TEST RESULTS AND FAILURE TO MEET STRENGTH REQUIREMENTS

A. Test results: Evaluate in accordance with ACI 214.

B. Evaluations shall be valid only if samples have been taken and tests have been conducted in accordance with ACI and ASTM specifications and methods as applicable.

C. If strength tests performed on concrete cylinders, cast at time concrete is placed, fail to meet specified 28-day values, or if samples have not been taken and tests conducted as specified, concrete represented by such samples and tests shall be considered questionable and shall be subject to further testing at expense of Contractor.

D. These additional tests of questionable concrete shall be performed by Independent Testing Agency, acceptable to Architect, and shall be conducted in accordance with ASTM C42. Concrete cores may be obtained in field, or load tests conducted and results evaluated in accordance with ACI 318.

E. Test results obtained by use of impact hammer or sonoscope, unless correlated with other data, will not be considered conclusive in evaluating strengths of concrete.

F. If additional testing fails to demonstrate strengths adequate for intended purpose of member or members in question, as determined by Architect, remove questionable concrete and replace with concrete meeting specifications.

END OF SECTION
SECTION 033300 - ARCHITECTURAL CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cast-in-place architectural concrete including form facings, reinforcement accessories, concrete materials, concrete mixture design, placement procedures, and finishes.

B. Related Requirements:
   1. Section 033000 "Cast-in-Place Concrete" for additional cast-in-place concrete information referenced by this Section.
   2. Section 079200 "Joint Sealants" for elastomeric joint sealants in contraction and other joints in cast-in-place architectural concrete.

1.2 DEFINITIONS

A. Cast-in-Place Architectural Concrete: Formed concrete that is exposed to view on surfaces of completed structure or building and that requires special concrete materials, formwork, placement, or finishes to obtain specified architectural appearance.

B. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.


D. Reveal: Projection of coarse aggregate from matrix or mortar after completion of exposure operations.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place architectural concrete to attend, including the following:
      a. Contractor's superintendent.
      b. Independent testing agency responsible for concrete design mixtures.
      c. Ready-mix concrete manufacturer.
1.4 SUSTAINABLE DESIGN REQUIREMENTS

A. The Owner requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 Sustainable Design Requirements, are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.

B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1. Indicate amounts of mixing water to be withheld for later addition at Project site.

D. Formwork Shop Drawings: Show formwork construction including form-facing joints, rustications, construction and contraction joints, form joint-sealant details, form tie locations and patterns, inserts and embedments, cutouts, cleanout panels, and other items that visually affect cast-in-place architectural concrete.

E. Placement Schedule: Submit concrete placement schedule before start of placement operations. Include locations of all joints including construction joints.

F. Samples: For each of the following materials:

1. Form-facing panel.
2. Form ties.
3. Form liners.
5. Chamfers and rustications.

G. Samples for Verification: Architectural concrete Samples, cast vertically, approximately 18 by 18 by 2 inches (450 by 450 by 50 mm), of finishes, colors, and textures to match design reference sample. Include Sample sets showing the full range of variations expected in these characteristics.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For [manufacturer] [testing agency].
B. Material Certificates: For each of the following:
1. Cementitious materials.
2. Admixtures.
3. Form materials and form-release agents.
4. Repair materials.

C. Material Test Reports: For the following, by a qualified testing agency:
1. Aggregates.

1.7 QUALITY ASSURANCE

A. Field Sample Panels: After approval of verification sample and before casting architectural concrete, produce field sample panels to demonstrate the approved range of selections made under Sample submittals. Produce a minimum of three sets of full-scale panels, cast vertically, approximately 48 by 48 by 6 inches minimum, to demonstrate the expected range of finish, color, and texture variations.
1. Locate panels as indicated or, if not indicated, as directed by Architect.
2. Demonstrate methods of curing, aggregate exposure, sealers, and coatings, as applicable.
3. In presence of Architect, damage part of an exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
4. Maintain field sample panels during construction in an undisturbed condition as a standard for judging the completed Work.
5. Demolish and remove field sample panels when directed.

B. Mockups: Before casting architectural concrete, build mockups to verify selections made under Sample submittals and to demonstrate typical joints, surface finish, texture, tolerances, and standard of workmanship. Build mockups to comply with the following requirements, using materials indicated for the completed Work:
1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Architect.
2. Build mockups of typical exterior wall of cast-in-place architectural concrete as shown on Drawings.
3. Demonstrate curing, cleaning, and protecting of cast-in-place architectural concrete, finishes, and contraction joints, as applicable.
4. In presence of Architect, damage part of the exposed-face surface for each finish, color, and texture, and demonstrate materials and techniques proposed for repair of tie holes and surface blemishes to match adjacent undamaged surfaces.
5. Obtain Architect's approval of mockups before casting architectural concrete.
6. Demolish and remove mockup when directed.

PART 2 - PRODUCTS

2.1 FORM-FACING MATERIALS

A. General: Comply with Division 03 Section "Cast-in-Place Concrete" for formwork and other form-facing material requirements.

B. Form-Facing Panels: To be selected by Architect.
1. Form-Facing Panels for As-Cast Finishes: Steel, glass-fiber-reinforced plastic, or other approved nonabsorptive panel materials that will provide continuous, true, and smooth architectural concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.

2. Form-Facing Panels for As-Cast Finishes: Exterior-grade plywood panels, nonabsorptive, that will provide continuous, true, and smooth architectural concrete surfaces, medium-density overlay, Class 1, or better, mill-applied release agent and edge sealed, complying with DOC PS 1.

C. Chamfer Strips: Metal, rigid plastic, elastomeric rubber, or dressed wood, 1/2 by 1/2 inch, maximum; nonstaining; in longest practicable lengths.

D. Form Joint Tape: Compressible foam tape; pressure sensitive; AAMA 800, "Specification 810.1, Expanded Cellular Glazing Tape"; minimum 1/4 inch thick.

E. Form Joint Sealant: Elastomeric sealant complying with ASTM C 920, Type M or Type S, Grade NS, that adheres to form joint substrates.

F. Sealer: Penetrating, clear, polyurethane wood form sealer formulated to reduce absorption of bleed water and prevent migration of set-retarding chemicals from wood.

G. Form-Release Agent: Commercially formulated, colorless form-release agent that will not bond with, stain, or adversely affect architectural concrete surfaces and will not impair subsequent treatments of those surfaces.

H. Surface Retarder: Chemical liquid set retarder, for application on form-facing materials, capable of temporarily delaying final hardening of newly placed concrete surface to depth of reveal specified.

I. Form Ties: Factory-fabricated, glass-fiber-reinforced plastic ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

   1. Furnish glass-fiber-reinforced plastic ties, not less than 1/2 inch in diameter, of color selected by Architect from manufacturer's full range.

2.2 STEEL REINFORCEMENT AND ACCESSORIES

A. General: Comply with Division 03 Section "Cast-in-Place Concrete" for steel reinforcement and other requirements for reinforcement accessories.

B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than [25] [60] <Insert number> percent.

C. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire fabric in place; manufacture according to CRSI's "Manual of Standard Practice."

   1. Where legs of wire bar supports contact forms, use CRSI Class 1, gray, plastic-protected or CRSI Class 2, stainless-steel bar supports.

2.3 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:
1. Portland Cement: ASTM C 150, Type I/II, gray or white as required by color selection. Supplement with the following:
   a. Fly Ash: ASTM C 618, Class C or Class F. Maximum 25% of total cementitious material for Class C and 20% of total cementitious material for Class F. Minimum amount of fly ash, when used 15% of total cementitious material.
   b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or Grade 120. Maximum 50 percent of total cementitious material.
   c. Combined pozzolanic mineral admixture or fly ash, and silica fume: 30% by total cementitious material with fly ash or pozzolans not exceeding 25%.
   d. Combined fly ash or other pozzolans, and ground granulated blast-furnace slag: 50% of total cementitious material.
   e. Use cementitious material that is of same brand and type and from same plant as used in the concrete mix design submittal.

B. Normal-Weight Aggregates: ASTM C 33, [Class 5S] [Class 5M] [Class 1N] <Insert class> coarse aggregate or better, graded. Provide aggregates from single source[ with documented service record data of at least 10 years' satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials].

   1. Maximum Coarse-Aggregate Size: 1/2 inch.
   2. Gradation: Uniformly graded.

C. Normal-Weight Fine Aggregate: ASTM C 33, manufactured or natural sand, from same source for entire Project.

D. Water: Potable, complying with ASTM C 94/C 94M except free of wash water from mixer washout operations.

2.4 ADMIXTURES


B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

   1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
   2. Retarding Admixture: ASTM C 494/C 494M, Type B.
   3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
   4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
   5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
   6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

C. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable,[ free of carbon black,] nonfading, and resistant to lime and other alkalis.

   1. Color: As selected by Architect from manufacturer's full range.

2.5 CURING MATERIALS

A. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.
B. Absorptive Cover: AASHTO M 182, Class 3, burlap cloth made from jute or kenaf.

C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

D. Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.
   1. For integrally colored concrete, curing compound shall be pigmented type approved by color pigment manufacturer.

2.6 REPAIR MATERIALS

A. Bonding Agent: ASTM C 1059/C 1059M, Type II, nonredispersible, acrylic emulsion or styrene butadiene.

B. Epoxy Bonding Adhesive: ASTM C 881/C 881M, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements.
   1. Types I and II, non-load bearing or Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

2.7 CONCRETE MIXTURES, GENERAL

A. Prepare design mixtures for each type and strength of cast-in-place architectural concrete proportioned on basis of laboratory trial mixture or field test data, or both, according to ACI 301.
   1. Use a qualified independent testing agency for preparing and reporting proposed design mixtures based on laboratory trial mixtures.

B. Proportion concrete mixtures in accordance with Section 033000 "Cast-in-Place Concrete."

2.8 CONCRETE MIXING

A. Ready-Mixed Architectural Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and furnish batch ticket information.
   1. Clean equipment used to mix and deliver cast-in-place architectural concrete to prevent contamination from other concrete.
   2. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 FORMWORK

A. General: Comply with Division 03 Section "Cast-in-Place Concrete" for formwork, embedded items, and shoring and reshoring.

B. Limit deflection of form-facing panels to not exceed ACI 303.1 requirements.
C. In addition to ACI 303.1 limits on form-facing panel deflection, limit cast-in-place architectural concrete surface irregularities, designated by ACI 347 as abrupt or gradual, as follows:
   1. Class A, 1/8 inch (3.2 mm).

D. Fabricate forms to result in cast-in-place architectural concrete that complies with ACI 117, “Specifications for Tolerances for Concrete Construction and Materials.”

E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast-in-place surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical. Kerf wood rustications, keyways, reglets, recesses, and the like, for easy removal.
   1. Seal form joints and penetrations at form ties with form joint tape or form joint sealant to prevent cement paste leakage.
   2. Do not use rust-stained steel form-facing material.

F. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

G. Do not chamfer exterior corners and edges of cast-in-place architectural concrete.

H. Coat contact surfaces of wood rustications and chamfer strips with sealer before placing reinforcement, anchoring devices, and embedded items.

I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

L. Coat contact surfaces of forms with form-release agent, according to manufacturer’s written instructions, before placing reinforcement.

M. Coat contact surfaces of forms with surface retarder, according to manufacturer’s written instructions, before placing reinforcement.

N. Place form liners accurately to provide finished surface texture indicated. Provide solid backing and attach securely to prevent deflection and maintain stability of liners during concreting. Prevent form liners from sagging and stretching in hot weather. Seal joints of form liners and form liner accessories to prevent mortar leaks. Coat form liner with form-release agent.

3.2 REINFORCEMENT AND INSERTS

A. General: Comply with Division 03 Section "Cast-in-Place Concrete" for fabricating and installing steel reinforcement. Securely fasten steel reinforcement and wire ties against shifting during concrete placement.

B. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
3.3 REMOVING AND REUSING FORMS

A. Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F (10 deg C) for 24 hours after placing concrete if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.
   1. Schedule form removal to maintain surface appearance that matches approved field sample panels.
   2. Cut off and grind glass-fiber-reinforced plastic form ties flush with surface of concrete.

B. Leave formwork for beam soffits, joists, slabs, and other structural elements that support weight of concrete in place until concrete has achieved [28-day design compressive strength] [at least 70 percent of 28-day design compressive strength]. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

C. Clean and repair surfaces of forms to be reused in the Work. Do not use split, frayed, delaminated, or otherwise damaged form-facing material. Apply new form-release agent.

D. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for cast-in-place architectural concrete surfaces.

3.4 JOINTS

A. Construction Joints: Install construction joints true to line with faces perpendicular to surface plane of cast-in-place architectural concrete so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
   1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise indicated.
   2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete. Align construction joint within rustications attached to form-facing material.
   3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
   4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
   5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
   6. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

B. Contraction Joints: Form weakened-plane contraction joints true to line with faces perpendicular to surface plane of cast-in-place architectural concrete so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.

3.5 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, form-release agent, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect.
C. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301.
   1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

D. Deposit concrete continuously between construction joints. Deposit concrete to avoid segregation.
   1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.
   2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 303.1.
   3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. Do not permit vibrators to contact forms.

E. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
   1. When average high and low temperature is expected to fall below 40 deg F (4.4 deg C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
   2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
   3. Do not use calcium chloride, salt, or other materials containing antifreeze agents.
   4. Do not use chemical accelerators unless otherwise specified and approved in design mixtures.

F. Hot-Weather Placement: Comply with ACI 301 and as follows:
   1. Maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
   2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

3.6 FINISHES, GENERAL

A. Architectural Concrete Finish: Match Architect's design reference sample, identified and described as indicated, to satisfaction of Architect.

B. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces.
   1. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

C. Maintain uniformity of special finishes over construction joints unless otherwise indicated.
3.7 AS-CAST FORMED FINISHES

A. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Remove fins and other projections exceeding specified limits on formed-surface irregularities. Repair and patch tie holes and defects.

3.8 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and with ACI 301 for hot-weather protection during curing.

B. Begin curing cast-in-place architectural concrete immediately after removing forms from concrete. Cure according to ACI 308.1, by one or a combination of the following methods that will not mottle, discolor, or stain concrete:

1. Moisture Curing: Keep exposed surfaces of cast-in-place architectural concrete continuously moist for no fewer than seven days with the following materials:
   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Cure for no fewer than seven days. Immediately repair any holes or tears during curing period; use cover material and waterproof tape.

3. Curing Compound: Mist concrete surfaces with water. Apply curing compound uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.9 FIELD QUALITY CONTROL

A. General: Comply with field quality-control requirements in Division 03 Section "Cast-in-Place Concrete."

3.10 REPAIRS, PROTECTION, AND CLEANING

A. Repair and cure damaged finished surfaces of cast-in-place architectural concrete when approved by Architect. Match repairs to color, texture, and uniformity of surrounding surfaces and to repairs on approved mockups.

1. Remove and replace cast-in-place architectural concrete that cannot be repaired and cured to Architect's approval.

B. Protect corners, edges, and surfaces of cast-in-place architectural concrete from damage; use guards and barricades.

C. Protect cast-in-place architectural concrete from staining, laitance, and contamination during remainder of construction period.
D. Clean cast-in-place architectural concrete surfaces after finish treatment to remove stains, markings, dust, and debris.

E. Wash and rinse surfaces according to concrete finish applicator’s written instructions. Protect other Work from staining or damage due to cleaning operations.
   1. Do not use cleaning materials or processes that could change the appearance of cast-in-place architectural concrete finishes.

END OF SECTION
SECTION 033543 - POLISHED CONCRETE FINISHING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes polished concrete finishing.

1. Project Concrete:
   a. Lower Level Slab-on-Grade: Normal Weight Concrete according to Section 033000 "Cast-in-Place Concrete" as modified in this section.
   b. Upper Level Suspended Slabs: Lightweight Concrete according to Section 033000 "Cast-in-Place Concrete" as modified in this section.

2. Concrete for polished concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, initial finishing, and curing is specified in Division 03. Coordinate requirements for materials, mixes with requirements indicated.

B. Related Requirements:

   1. Section 033000 "Cast-in-Place Concrete" for concrete not designated as polished concrete and for use of additives and curing compounds in areas designated to be polished.

1.3 DEFINITIONS


1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

   1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with polished concrete to attend, including the following:
      a. Contractor's superintendent.
      b. Independent testing agency responsible for concrete design mixtures.
      c. Ready-mix concrete manufacturer.
      d. Cast-in-place concrete subcontractor.
      e. Polished concrete finishing Subcontractor.

   2. Review curing procedures, construction joints, concrete repair procedures, concrete finishing, and protection of polished concrete.
1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Polishing Schedule: Submit plan showing polished concrete surfaces and schedule of polishing operations for each area of polished concrete before start of polishing operations. Include locations of all joints, including construction joints.

D. Samples for Verification: For each type of exposed color matching Architect's Sample.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Material Certificates: For each of the following, signed by manufacturers:
   1. Liquid floor treatments.

1.7 QUALITY ASSURANCE

A. Installer Qualification: Approved by concrete polishing system manufacturer with a minimum of five similar successful projects within the past three years.

B. Field Sample Panels: After approval of verification sample and before casting concrete, produce field sample panels to demonstrate the approved range of selections made under Sample submittals. Produce a minimum of four sets of full-scale panels, approximately 48 by 48 inches minimum each, to demonstrate the expected range of finish, color, and appearance variations.

   1. Locate panels as indicated or, if not indicated, as directed by Architect.
   2. Maintain field sample panels during construction in an undisturbed condition as a standard for judging the completed Work.
   3. Demolish and remove field sample panels when directed.
   4. Include finish samples in the following polish levels for review and selection by District and Architect. Selected sample will be used as Design Reference Sample:

      a. Level 1: Matte finish, 100 grit
      b. Level 2: Low sheen (Matte), 400 grit
      c. Level 3: High sheen (Semi-gloss), 800 grit

C. Mockup: After selection of final Field Sample Panel and before casting concrete floor, build mockup to verify selections made and to demonstrate typical joints, surface finish, tolerances, and standard of workmanship. Build mockups to comply with the following requirements, using materials indicated for the completed Work:

   1. Build mockup in the location and of the size indicated or, if not indicated, as directed by Architect.
   2. Demonstrate curing, staining, finishing, and protecting of polished concrete.
   3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
1.8 FIELD CONDITIONS

A. Traffic Control: Maintain access for pedestrian traffic as required for other construction activities.

PART 2 - PRODUCTS

2.1 CONCRETE POLISHING SYSTEM, GENERAL

A. Source Limitations: Obtain polishing system materials, including treatments and finishing products, from a single manufacturer.

B. Dynamic Coefficient of Friction: Provide polished concrete installed on walkway surfaces with dynamic coefficient of friction indicated as determined by testing identical products per ANSI A137.1 DCOF AcuTest procedure.
   1. Dynamic Coefficient of Friction: Not less than 0.42.

2.2 BASIS-OF-DESIGN SYSTEM

A. Project system is based on products and performance provided by Floor Seal Technology, Inc.
   1. Stain: None.
   2. Cut: Matte, 400 - 800 grit, to be verified with sample panels and mockup.
   5. Lightweight Aggregate: Pumice
   7. Additives: 30 percent slag to produce selected mix. No fly ash. Aggregates shall be knocked down during concrete finishing to produce sanded cutting surface.
   8. Use plastic trowel blades - do not burnish.
   9. No silicate curing compounds.
   10. Spread curing compounds into joints to reduce curling.
   11. FF/FL: 40/30.

B. Other comparable products include the following but must be part of a sole-sourced system matching the specified requirements for performance and aesthetics.
   1. Americrete
   2. Ardex Americas.
   3. Artcrete
   4. Euclid Chemical Company (The), an RPM company

2.3 LIQUID FLOOR TREATMENTS

A. Penetrating Liquid Floor Treatments for Polished Concrete Finish: Clear, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; that penetrates, hardens, and is suitable for polished concrete surfaces.
   1. Products: Subject to compliance with requirements, provide the following or comparable from listed manufacturer or Architect approved equal:
      a. Floor Seal Technologies, Inc.; MirrorCrete

B. Finish Protection for Polished Concrete Finish: Clear, waterborne, reactive micro-impregnating polymer or penetrating solution for increased abrasion and stain resistance.
1. Products: Subject to compliance with requirements, provide the following or comparable from listed manufacturer or Architect approved equal:
   a. Floor Seal Technologies, Inc.; MirrorSealer

2.4 CONCRETE POLISH EQUIPMENT AND TOOLING

A. Equipment and tooling equipment as recommended by concrete polishing system products manufacturer for use as part of the multi-step dry mechanical process and accessories. As instructed by the concrete polishing system manufacturer, acceptable products may include:

   1. Planetary Grinder and Polisher:
      a. Large Platform, typically, 32-inch planetary floor polisher with head pressure of 600 pounds.
      b. Tooling:
         1) Metal Bonded Diamonds - 60-80 grit of medium bonded metal
         2) Transitional Diamonds Ceramic / Flat block resin bonded - 100 Grit
         3) Resin Bonded Diamonds - 100 and higher grit, as needed
   2. Micro-Polisher:
      a. Specific weight and RPM are required to reach temperature of 100 deg F for application of concrete final sealer.
      b. Required Tooling: Diamond Impregnated - 400, 800 grit, as needed
   3. Other equipment and tooling as necessary for small areas and edge work.
   4. Grinding and polishing equipment shall be be connected to a dust collector.

PART 3 - EXECUTION

3.1 EXECUTION, GENERAL

A. Inspect condition of existing concrete to be polished in the presence of Architect, polishing subcontractor, and concrete repair and treatment material manufacturer's representative. Determine whether repairs are required. If required, follow the preparation and application procedures for priming and placing repair and topping material prior to polishing. If repair is not required, skip directly to polishing procedures below.

3.2 PREPARATION

A. Joint and Crack Preparation: Honor joints and moving cracks up through the topping material, including expansion joints, isolation joints and control joints (saw cuts).

B. Fill non-moving cracks with joint and crack repair filler as instructed by topping and polishing material manufacturer.

3.3 POLISHING, GENERAL

A. Polish: Match design reference sample approved in Mockup.

B. Apply polished concrete finish system to cured and prepared slabs to match accepted mockup.
   1. Machine grind floor surfaces to receive polished finishes level and smooth.
2. Apply reactive stain for polished concrete in polishing sequence and according to manufacturer’s written instructions.
3. Provide surface with sand exposure only. Aggregate exposure not acceptable.

3.4 POLISHING PROCEDURES

A. The following is a general guideline for polishing procedures. Verify with system manufacturer's recommendations and written instructions, while relying on polishing experience for best results. However, additional steps may be required based on site conditions, age of installation, and desired finish.

1. Knock down aggregates in wet concrete with pin roller or similar float device and allow concrete to cure taking appropriate steps to ensure final product matching design Reference sample. Broadcast decorate flakes if required.
2. Step #1: Grind floor with 60-80 grit Metal Bonded Diamonds. Vacuum floor after each grinding/polishing step to remove dust.
3. Step #2: Grind with 100 grit Transitional, Ceramic / Flat block Resin Bonded Diamonds. Vacuum floor after each grinding/polishing step to remove dust.
4. Step #3: Grind/Hone with 200 grit Resin Bonded Diamond. Vacuum floor after each grinding/polishing step to remove dust.
5. Apply liquid floor treatment in accordance with manufacturer's application instructions. Allow to dry before beginning the next step.
6. Step #4: Grind/Polish with 400 grit Resin Bonded Diamond. Vacuum floor after each grinding/polishing step to remove dust. Proceed with successively higher grits until desired gloss level is achieved.
7. Apply finish sealer material in accordance with manufacturer's application instructions. Allow to dry before beginning the next step.
8. Step #5: Micro-polish with 400 to 800 grit pad. Do not burnish concrete. Dry, micro fiber mop the floor remove all debris. Floor should be allowed to cool to room temperature prior to second application.
9. Apply second coat of finish protection material in accordance with manufacturer's application instructions. Allow to dry.

3.5 EDGEWORK AND JOINT COMPLETION

A. Where needed, polished edge work shall be done with a hand held or walk behind polishing tool. The edge polishing process shall match the corresponding steps outlined above for the desired gloss level. Edge work steps should always precede the corresponding polisher steps.

B. Upon completion of polishing work, fill moving joints with indicated joint sealant.

3.6 PROTECTION

A. Protect the new polished concrete from spills and contamination by petroleum, oil, hydraulic fluid, acid and acidic detergents, paint and other liquid dripping from trades and equipment working over these substrates. If construction equipment must be used on these substrates, diaper all components that may drip fluids. Protect surface by installing a temporary, breathable protective floor covering.

B. Avoid moisture for a minimum of 72 hours after installation as instructed by system manufacturer.
C.  Do not place any protective plastic sheeting, rubber matting, rugs, or furniture that will trap moisture or prevent proper drying, which can result in a cloudy effect on the floor. Use pulp-based material only.

D.  Limit pedestrian use until 24 hours after installation. Normal pedestrian use may occur after 7 days.

3.7 MAINTENANCE

A.  Demonstrate proper maintenance to District's representative of the newly polished concrete floor.

3.8 FIELD QUALITY CONTROL

A.  Engage special testing agency to perform the following tests.
   1. Static Coefficient of Friction: A reading of not less than 0.5 for level floor surfaces shall be achieved and documented, as determined by a certified NFSI walkway auditor using the NFSI 101-A quality control test.
      a. Readings shall be taken not less than 10-feet on center in field areas and within 1-foot of floor area perimeters. In no case shall a reading be below 2-percent of the acceptable minimum sheen.

B.  Test Reports: Provide field quality control sheen gloss reading and static coefficient of friction test results conducted as specified and recorded on floor plan diagram confirming compliance with specified performance criteria.

END OF SECTION
SECTION 033546 - SEALED CONCRETE FINISHING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes sealed concrete finishing.
   1. Concrete for sealed concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, initial finishing, and curing is specified in Section 033000 "Cast-in-Place Concrete."

1.3 PREINSTALLATION MEETINGS
A. Preinstallation Conference: Conduct conference at Project site.
   1. Review curing procedures, concrete finishing, and protection of sealed concrete before and after sealer application.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product.
B. Sustainable Design Submittals required by Section 01813 applicable to this Section.
C. Sample Panels:
   1. Provide three 24-inch by 48-inch by 2-inch thick sample panels using concrete materials equivalent to concrete utilized for the Project, or from actual delivered batch, coated with sealer as follows:
      a. Panel 1: One coat.
      b. Panel 2: Two coats.
      c. Panel 3: Two coats with slip-resistant micro-media material.
   2. Sample panels will be used for final selection by Architect, with approval by Owner, and will set quality and workmanship for Work to be performed.

1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data: For Installer.
B. Material Certificates: For each of the following, signed by manufacturers:
   1. Liquid floor treatments.
1.6 QUALITY ASSURANCE

A. Mockups: Before applying sealer, build mockups to verify selections made under Sample submittals and to demonstrate typical joints, surface finish, tolerances, and standard of workmanship. Build mockups to comply with the following requirements, using materials indicated for the completed Work:

1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Architect.
2. Demonstrate curing, finishing, and protecting of sealed concrete.
3. Mock-ups and field test areas are required in order to validate performance and appearance related characteristics (including but not limited to color, inherent surface variations, wear, anti-dusting, abrasion resistance, chemical resistance, stain resistance, coefficient of friction, etc.) to ensure system performance as specified for the intended use, and to determine approval of the finish flooring system.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

B. Verify compatibility of sealer material with concrete curing admixtures prior to concrete placement to ensure compatibility. Provide curing products and concrete admixtures that are compatible with finish coat in locations indicated to receive finish coat.

1.7 FIELD CONDITIONS

A. Traffic and Stain Control: For cast-in-place concrete slabs scheduled to receive sealer, protect concrete from foot traffic, construction chemicals, spills, and stains prior to, and during sealer application to ensure uniform quality and look of freshly placed concrete.

B. Environmental Limitations: Comply with sealer manufacturer's written instructions for substrate temperature, ambient temperature, moisture, ventilation, and other conditions affecting sealer application.

C. Lighting: Provide permanent lighting or, if permanent lighting is not in place, simulate permanent lighting conditions during sealer application.

D. Close spaces to traffic during sealer application and for 24 hours after application.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Dynamic Coefficient of Friction: Provide sealed concrete installed on walkway surfaces with dynamic coefficient of friction indicated as determined by testing identical products per ANSI A137.1 DCOF AcuTest procedure.

1. Dynamic Coefficient of Friction: Not less than 0.42.

2.2 SEALER MATERIALS

A. Sealer/Finisher, Type C-1: Two-part polyaspartic aliphatic polyurea.
1. **Products:** Subject to compliance with requirements, provide Spartacote Flex Pure Clinical Plus as manufactured by Laticrete International Inc., or Architect approved equal with the following characteristics:
   b. Color and Gloss: Clear, gloss.
   c. Tensile strength: 4500 psi, minimum
   d. Low VOC
   e. Integral Antimicrobial Additive: Silver-ion, or equal.
   f. UV-resistant
   g. USDA acceptable.
   h. Chemical and stain resistant.

2. **Provide manufacturer's slip-resistant micro-media material** if selected for finish coat during Sample panel selection process, or as indicated on the drawings.

**PART 3 - EXECUTION**

3.1 **PREPARATION**

A. Prepare and clean substrates according to sealer manufacturer's written instructions for substrate indicated. Provide clean, dry substrate for sealer application.

B. Concrete Substrates: Provide sound concrete surfaces free of laitance, glaze, efflorescence, curing compounds, form-release agents, dust, dirt, grease, oil, and other contaminants incompatible with sealer or that provide a splotchy end product.

1. Roughen concrete substrates as follows:
   a. Grind concrete to an ICRI CSP-2 profile or the equivalent of 30-60-grit sandpaper using a surface grinder equipped with metal bond diamonds.
   b. Comply with ASTM C 811 requirements unless manufacturer's written instructions are more stringent.

2. Repair damaged and deteriorated concrete according to sealer manufacturer's written instructions.

3. Verify that concrete substrates are dry and moisture-vapor emissions are within acceptable levels according to manufacturer's written instructions.

   a. Anhydrous Calcium Chloride Test: ASTM F 1869. Proceed with application of resinous flooring only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. of slab area in 24 hours.
   b. Plastic Sheet Test: ASTM D 4263. Proceed with application only after testing indicates absence of moisture in substrates.
   c. Relative Humidity Test: Use in situ probes, ASTM F 2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.
   d. If water moisture tests exceed stated limits, apply vapor retarder for moisture vapor emission control as specified in Section 090561.13.

4. **Alkalinity and Adhesion Testing:** Verify that concrete substrates have pH within acceptable range. Perform tests recommended by manufacturer. Proceed with application only after substrates pass testing.

C. **Sealer Materials:** Mix components and prepare materials according to manufacturer's written instructions.
D. Lightweight Concrete Slabs: Verify compatibility of concrete sealer products with use on lightweight concrete. Prepare slab as instructed by sealer manufacturer.

3.2 APPLICATION

A. Apply components of sealer according to manufacturer's written instructions to produce a uniform, monolithic wearing surface of thickness indicated.
   1. Coordinate application of components to provide optimum adhesion of sealer material to substrate, and optimum intercoat adhesion.
   2. Cure sealer components according to manufacturer's written instructions. Prevent contamination during application and curing processes.

B. If required or indicated, add slip-resistant micro-media agents after thoroughly mixing A and B components in accordance with sealer manufacturer's written instructions.

C. Application thickness: 8 mils per coat, or equivalent to 200 square feet per coat per gallon.

D. Topcoats: Apply topcoats in number indicated for flooring system and at spreading rates recommended in writing by manufacturer and to produce wearing surface indicated.

3.3 PROTECTION

A. Protect sealed concrete floor from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by sealer manufacturer.

END OF SECTION
SECTION 036100 - GROUTED DOWELS IN CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes:
   1. Reinforcing bar dowels installed in hardened concrete using adhesive prepackaged in cartridges.
   2. Reinforcing bar dowels and threaded bar anchors installed in hardened concrete using nonshrink grout.

B. Related Sections:
   1. Section 050525 – Post-Installed Concrete Anchors for installation of adhesive anchors for attachment of nonstructural and structural components.

1.3 REFERENCES

A. Standards listed below apply where designation is cited in this Section. Where the applicable year of adoption or revision is not listed below, the latest edition applies.

B. ASTM: Standards of the American Society for Testing and Materials (ASTM) apply where designated in this Section.


D. ICC-ES: ICC Evaluation Service:

1.4 SUBMITTALS

A. Submittal procedures and administrative provisions are established by Division 01 Section "Submittals".

B. Product data for proprietary materials, including epoxy adhesives and nonshrink grout. Include manufacturer's detailed instructions for storage and handling, installation, and special inspection.
   1. Include current ICC Evaluation Service Report for adhesives prepackaged in cartridges.
1.5 QUALITY ASSURANCE

A. Cartridge Adhesive: Products proposed for use shall have an active ICC Evaluation Service Report evidencing compliance with ICC ES acceptance criteria AC308 for use to resist tension and shear in cracked and uncracked concrete.

1. Installation shall conform to manufacturer’s written instructions listed in ICC ES report.

PART 2 - PRODUCTS

2.1 ADHESIVE AND GROUT MATERIALS

A. Cartridge Adhesive

1. Epoxy Adhesive: Two-component, 100% solids, structural epoxy conforming to ASTM C881, Type IV; Grade 3; prepackaged in cartridges for manually or pneumatically operated caulk gun and automatically mixed at nozzle. Approved for use in cracked and uncracked concrete in accordance with ICC ES AC308, as demonstrated by an active ICC Evaluation Service Report. Subject to compliance with specified requirements, provide one of the following, or equal:

   HIT-RE 500-V3 Adhesive, Hilti Inc. (ICC ESR-3814)
   Set-XP Epoxy Adhesive, Simpson Strong-Tie Co. (ICC ESR-2508)

2. Hybrid Adhesive: Two-component, hybrid adhesive prepackaged in cartridges for manually or pneumatically operated caulk gun and automatically mixed at nozzle. Approved for use in cracked and uncracked concrete in accordance with ICC ES AC308, as demonstrated by an active ICC or IAPMO Evaluation Service Report. Subject to compliance with specified requirements, provide one of the following, or equal:

   HIT-HY 200 Adhesive, Hilti Inc. (ICC ESR-3187)
   AT-XP Adhesive, Simpson Strong-Tie Co. (UES-ER-0263)

B. Nonshrink Grout: Premixed, nonmetallic, noncorrosive product, complying with ASTM C1107, Class B or C, at fluid consistency. Non-bleeding after mixing at a 27 (plus or minus 3 second) flow, ASTM C939, at 45 to 90 degrees F. Will pass through flow cone 45 minutes after initial mixing without the addition of water. Subject to compliance with requirements, provide one of the following:

   Euco N.S., Euclid Chemical Co.
   Masterflow 928, Master Builders
   Five Star Grout, U.S. Grout Corp.

2.2 DOWELS

A. Reinforcing Bars: ASTM A615, Grade 60, or ASTM A706, deformed. Embedded end shall be free of offsets that interfere with installation.
PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas to be drilled to verify conditions of access, interferences, and existing materials.
B. Locate existing reinforcing steel, which might interfere with drilling, with a suitable metal detector or by chipping.

3.2 PREPARATION
A. Protect existing exposed surfaces from grouting operations.
B. Dowels shall be free of oil, mud, loose rust or other materials that may reduce bond.

3.3 INSTALLATION WITH CARTRIDGE ADHESIVE
A. General: Install anchors in accordance with manufacturer’s written instructions, including drilling, hole cleaning, dispensing of epoxy and setting of dowels.
B. Adhesive Type: Approved hybrid adhesives shall be acceptable where designated embedment depth is 12 inches or less. Hybrid adhesives shall not be acceptable for dowels with deeper embedment; use epoxy adhesive.
C. Drilling:
   1. Drilling Equipment: Use electric or pneumatic rotary type drilling hammer with medium or light impact and carbide tipped masonry bit. Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking during drilling process.
   2. Do not cut reinforcing steel, except with approval of Owner's Representative. Where reinforcing is encountered, drill new hole a minimum of 2 diameters clear at no additional cost to Owner.
D. At overhead applications, use manufacturers standard hole plug to prevent epoxy leakage and temporarily support dowel to prevent movement out of hole. Hybrid adhesive is preferred for overhead application, where embedment depth permits use.
E. Fill abandoned holes with nonshrink grout.

3.4 INSTALLATION WITH NONSHRINK GROUT
A. Drill holes to a diameter 1-inch minimum larger than the nominal diameter of the dowels.
B. Drill holes using water-cooled core drilling equipment. Roughen surface by method acceptable to Owner's Representative.
C. Clean hole by flushing with water hose inserted to back of hole until water runs clear, brush twice with round steel wire bristle brush of appropriate diameter, and flush with hose until water runs clear.
D. Place reinforcing bar into hole. Provide centralizing devices as required to maintain bar at center of core.

E. Mix and place grout at fluid consistency in accordance with manufacturer's recommendations.

F. Cure by covering with wet cloth for 3 days minimum or by coating with curing compound.

3.5 CLEANING

A. Clean excess epoxy from around holes before it hardens only on surfaces that will not be exposed to view.

B. On surfaces that will be exposed to view, allow epoxy to cure then chip away hardened epoxy. Surfaces shall be repaired to match existing finish to the satisfaction of the Owner's Representative.

3.6 PROTECTION

A. Protect dowels from accidental disturbance during setting time specified by manufacturer.

B. Do not place pull-out or shear loads on dowels during curing time specified by manufacturer.

3.7 FIELD QUALITY CONTROL

A. Inspection and testing will be performed in accordance with procedures and administrative requirements of Division 01 Section, "Quality".

B. Testing Agency will:
   1. Review manufacturer's recommended installation and inspection procedures, as contained in ICC Evaluation Service Report.
   2. Special Inspect installation for conformance with Contract Documents, manufacturer's recommendations, and requirements of the applicable ICC-ES report.
   3. Test dowels in accordance with requirements of CBC Section 1910A.5 for adhesive anchors.
      a. Testing Procedure: Use hydraulic ram testing procedure of CBC Section 1910A.5.5 for testing of bond (confined configuration).
      b. Test Loads: As shown on Drawings, or as otherwise designated by Owner's Representative, in conformance with test load requirements CBC Section 1910A.5.4.
      c. Testing Frequency: 100 percent, except frequency can be reduced in accordance with CBC Section 1910A.5.3.
      d. Acceptance Criteria: Maintain test load for a minimum of 15 seconds with no discernible movement of dowel out of hole.

END OF SECTION
SECTION 040413 - COMMON SUBMITTAL REQUIREMENTS FOR MASONRY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary
      Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. This Section includes the following:
      1. Supplementary administrative and procedural requirements for submitting Shop
         Drawings, Product Data, Samples, and other submittals specific to the work of this
         Division.
   B. Related Requirements:
      1. Division 01 submittal requirements.

1.3 DEFINITIONS
   A. Contractor:  Refers to an entity in direct Contract with the Owner to furnish and/or perform any
      portion of the Work of the Contract.
      1. Contractor shall review and approve Product Submittals prior to forwarding them to the
         Architect.
   B. Product Submittals:  In general, Product Submittals show characteristics of the proposed
      construction in one of the following forms:
      1. Shop Drawings.
      2. Product Data.
      3. Samples.
   C. Action Submittals:  Written and graphic information and physical samples that require
      Architect/Engineer's responsive action.  Action submittals are those submittals indicated in
      individual Specification Sections as "action submittals."
   D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design
      Requirements."  Submit documentation for products and materials contributing to achievement
      of LEED rating indicated.  Sustainable Design Submittals are in addition to other submittal
      requirements.
   E. Informational Submittals:  Written and graphic information and physical samples that do not
      require Architect/Engineer's responsive action.  Submittals may be rejected for not complying
      with requirements.  Informational submittals are those submittals indicated in individual
      Specification Sections as "informational submittals."
   F. Submittal Review Sheet:  Specific form required to accompany each submittal.  Obtain
      Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
   a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Refer to Section 01330 for quantity of days allowed for review.
2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:
   1. Action Codes Permitting Use:
      a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
      b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
      c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
   1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering

1. Number submittals as described below to assist tracking.

2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 042113 - BRICK MASONRY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Clay face brick.
   2. Thin brick.
   3. Mortar and adhesive.
   4. Ties and anchors.
   5. Embedded flashing.
   6. Miscellaneous masonry accessories.
   7. Water repellent and graffiti control.

B. Products Installed but not Furnished under This Section:
   1. Steel lintels in masonry veneer.
   2. Steel shelf angles for supporting masonry veneer.
   3. Joint sealant at deflection/story drift joints and control joints.

C. Related Requirements:
   1. Section 051200 "Structural Steel Framing" for installing anchor sections of adjustable masonry anchors for connecting to structural steel frame.
   2. Section 061600 "Sheathing" for glass-mat gypsum sheathing substrate with continuous water-resistive barrier.
   3. Section 061600 "Sheathing" for cement board wall sheathing substrate for adhered thin brick applications.
   4. Section 072100 "Thermal Insulation" for composite thermal spacer support system used as part of thin brick application assembly.
   5. Section 072726 "Membrane Air Barriers" for fluid-applied water-resistive air barrier used as part of brick veneer assemblies.
   6. Section 076200 "Sheet Metal Flashing and Trim" for sheet metal flashing and for furnishing manufactured reglets installed in masonry joints.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For the following:
   1. Masonry Units: Show sizes, profiles, coursing, and locations of special shapes.
   2. Fabricated Flashing: Detail corner units, end-dam units, and other special applications.
D. Samples for Verification: For each type and color of the following, based on Architect's previously selected products:

1. Clay face brick, in the form of straps of five or more bricks; one with each type of sealer and one unsealed.
2. Thin brick, in the form of straps of five or more bricks; one with each type of sealer and one unsealed.
3. Pigmented mortar. Make Samples using same sand and mortar ingredients to be used on Project, if any.
5. Accessories embedded in masonry.
6. Masonry sealer and graffiti control applied to one-half of brick sample straps.

E. Test Reports:

1. Anchors, ties, and metal accessories, including ES reports as applicable.

1.4 QUALITY ASSURANCE

A. Provide the following upon request:

1. Material Certificates: For each type and size of the following:
   a. Masonry units.
      1) Include material test reports substantiating compliance with requirements.
      2) For brick, include size-variation data verifying that actual range of sizes falls within specified tolerances.
      3) For exposed brick, include test report for efflorescence according to ASTM C 67.
      4) For masonry sealers and graffiti control products.
   b. Cementitious materials. Include name of manufacturer, brand name, and type.
   c. Mortar admixtures.
   d. Preblended, dry mortar mixes. Include description of type and proportions of ingredients.

B. Mockups: Build mockups using approved Samples, to demonstrate aesthetic effects, and to set quality standards for materials and execution.

1. Build mockup according to Mockup Drawing as shown on Drawings.
2. Include each type of exposed brick masonry construction in in exterior envelope mockup in accordance with Section 01450 "Mockup Requirements," including accessories.
   a. Include a sealant-filled joint at least 16 inches long in each mockup.
   b. Include through-wall flashing installed for a 24-inch length in corner of exterior wall mockup approximately 16 inches down from top of mockup, with a 12-inch length of flashing left exposed to view (omit masonry above half of flashing).
   c. Include metal studs, sheathing, water-resistant barrier, veneer anchors, flashing, cavity drainage material, and weep holes in exterior masonry-veneer wall mockup.
   d. Include portion of metal wall panels built into brick masonry to demonstrate interface transition and compatibility. Include flashing and sealant.
3. Water Repellant and Graffiti Control: Test a minimum 48- by 48-inch area on each type of masonry. Use the manufacturer's application instructions. Let test area protective treatment cure before inspection. Keep test panels available for comparison throughout the protective treatment project.
   a. Demonstrate graffiti removal to Owner and Architect.
4. Clean exposed faces of mockups with masonry cleaner as indicated.
5. Protect accepted mockups from the elements with weather-resistant membrane.

   a. Approval of mockup also includes color, texture, and blending of masonry units; relationship of mortar and sealant colors to masonry unit colors; tooling of joints; and aesthetic qualities of workmanship.
   b. Approval of mockups is also for other material and construction qualities specifically approved by Architect in writing.
   c. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, from single source from single manufacturer for each product required.

   1. Product: Subject to compliance with requirements, match Architect’s Sample as follows, or Architect approved equal:
      
      a. Size: Norman
      b. Pattern: Refer to Drawings for pattern and protrusions.

         1) Pattern 1:
            i. Manufacturer: Belden Brick
            ii. Color: Alaska White Velour

         2) Pattern 2:
            i. Manufacturer: Belden Brick
            ii. Color: Contra Costa Blend

B. Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from single manufacturer for each cementitious component and from single source or producer for each aggregate. All brick supplied must be pre-blended by the manufacturer.

2.2 UNIT MASONRY, GENERAL

A. Masonry Standard: Comply with TMS 602/ACI 530.1/ASCE 6, except as modified by requirements in the Contract Documents.

B. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated. Do not use units where such defects will be exposed in the completed Work and will be within 20 feet vertically and horizontally of a walking surface.

C. Fire-Resistance Ratings: Comply with requirements for fire-resistance-rated assembly designs indicated.

2.3 BRICK

A. Regional Materials: Brick shall be manufactured within 500 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site.
B. General: Provide shapes indicated and as follows, with exposed surfaces matching finish and color of exposed faces of adjacent units:

1. For ends of sills and caps and for similar applications that would otherwise expose unfinished brick surfaces, provide units without cores or frogs and with exposed surfaces finished.
2. Provide special shapes for applications where stretcher units cannot accommodate special conditions, including those at corners, movement joints, bond beams, sashes, and lintels.
3. Provide special shapes for applications requiring brick of size, form, color, and texture on exposed surfaces that cannot be produced by sawing.
4. Provide special shapes for applications where shapes produced by sawing would result in sawed surfaces being exposed to view.
5. All special shapes are to be manufactured per Architectural details, no cuts for special shapes are to be made on site.

C. Clay Face Brick: Facing brick complying with ASTM C 216.

1. Grade: MW above-grade and SW below-grade.
2. Type: FBX.
3. Additional Requirements:
   a. Under no circumstances may the saturation coefficient requirements of ASTM C216, Table 1 Physical Requirements be waived.
   b. The minimum compressive strength of an individual brick shall be 34.5 MPa (5000 psi).
   c. Brick shall pass the freezing and thawing test as described in ASTM C67.
   d. Brick shall pass the efflorescence test as "not effloresced" as described in ASTM C67.

D. Thin Brick: Veneer brick complying with ASTM C1088.

1. Grade: Exterior
2. Type: TBX.
3. Thickness: 1/2-inch
4. Additional Requirements:
   a. Under no circumstances may the saturation coefficient requirements of ASTM C216, Table 1 Physical Requirements be waived.
   b. The minimum compressive strength of an individual brick shall be 34.5 MPa (5000 psi).
   c. Brick shall pass the freezing and thawing test as described in ASTM C67.
   d. Brick shall pass the efflorescence test as "not effloresced" as described in ASTM C67.

2.4 MORTAR MATERIALS

A. Portland Cement: ASTM C 150/C 150M, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.

1. Alkali content shall not be more than 0.1 percent when tested according to ASTM C 114.

B. Hydrated Lime: ASTM C 207, Type S.

C. Aggregate for Mortar: ASTM C 144.

1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.
2. For joints less than 1/4 inch thick, use aggregate graded with 100 percent passing the No. 16 sieve.


E. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing no other ingredients.
   1. Manufacturer: Spec Mix Inc., or Architect approved equal.

F. Cold-Weather Admixture: Nonchloride, noncorrosive, accelerating admixture complying with ASTM C 494/C 494M, Type C, and recommended by manufacturer for use in masonry mortar of composition indicated.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. GCP Applied Technologies Inc. (formerly Grace Construction Products).

G. Water: Potable.

2.5 PREBLENDED MORTAR MATERIALS

A. Mortar Adhesive for Thin-set Adhered Masonry Applications: ANSI A118.4; lightweight, non-sag, polymer modified thin-set mortar.
   1. Product: Subject to compliance with requirements, provide the following, or Architect approved equal:
      a. Laticrete International, Inc.; MVIS Masonry Veneer Mortar

B. Moisture Barrier for Thin-set Adhered Masonry Applications: ANSI A118.10 and ANSI A118.12; Fluid-applied, nailable, single component, load bearing, waterproofing, crack isolation, and air barrier membrane used as primer for masonry veneer thinset mortar over cement board.
   1. Product: Subject to compliance with requirements, provide the following, or Architect approved equal:
      a. Laticrete International, Inc.; MVIS Air & Water Barrier

C. Water: Potable.

2.6 TIES AND ANCHORS

A. General: Ties and anchors shall be coated to provide thermal break to decrease thermal transfer through rigid insulation, and shall extend at least 1-1/2 inches into veneer but with at least a 5/8-inch cover on outside face.
   1. Acceptable Manufacturers: Subject to compliance with requirements, provide listed product or equal by one of the following:
      a. Heckmann Building Products, Inc.
      b. Wire-Bond.
   2. Changes to the specified tie/anchor is subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

B. For locations where typical anchor cannot be used, provide the following:
1. Fabricate sheet metal anchor sections and other sheet metal parts from 0.109-inch-thick, stainless-steel sheet.
   a. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, Type 316.

C. Stainless-Steel Wire: ASTM A 580/A 580M, Type 316.
   1. Diameter: 3/16-inch

D. Adjustable Masonry-Veneer Anchors and Ties, typical, unless otherwise indicated:
   1. General: Provide anchors that allow vertical adjustment but resist a 200-lbf load in both tension and compression perpendicular to plane of wall without deforming or developing play in excess of 1/16 inch.
      a. Polymer-Coated, Steel Drill Screws for Steel Studs: ASTM C 954 except manufactured with hex washer head. Screw diameter by length required to penetrate steel stud flange with not less than three exposed threads through insulation and exterior sheathing, and with organic polymer coating with salt-spray resistance to red rust of not less than 1000 hours according to ASTM B 117.
      b. Stainless-Steel Barrels: ASTM A 580/A 580M, Type 316.
      c. Washer: 1-1/2-inch diameter, Stainless-Steel, Type 316
      d. Adjustment: Up to 1/2-inch.
   2. Adjustable Veneer-Anchor: Single screw veneer anchor for metal stud construction with a polymer-coated dual-diameter barrel screw, factory-installed washers to seal both the face of the insulation and the air/vapor barrier, and adjustable steel-reinforced plastic-coated wings to accept compressed leg seismic hook.
      a. Basis-of-Design Product: Subject to compliance with requirements, provide the following, or Architect approved equal:
         1) Hohmann & Barnard, Inc.; Thermal 2-Seal Wing Nut Anchor.
   3. Compressed Leg Seismic Hook/Pintle: Engage with wing nut anchor and continuous wire.
      a. Basis-of-Design Product: Subject to compliance with requirements, provide the following, or Architect approved equal:
         1) Hohmann & Barnard, Inc.; SH-2X-Seismic Hook.
      b. Length: As required, verify.
      c. Thickness: 3/16-inch
      d. Stainless-Steel: ASTM A 580/A 580M, Type 316.

2.7 EMBEDDED FLASHING MATERIALS

A. Masonry flashing shall be metal, except as otherwise noted. Metal flashing shall be through-wall, where feasible, except where otherwise clearly shown or noted. Through-wall flashing shall be 2-piece, except where otherwise clearly shown or noted.

B. Metal Flashing: Provide metal flashing complying with SMACNA's "Architectural Sheet Metal Manual" and as follows to suit condition and masonry color:
   1. Stainless Steel: ASTM A 240, Type 316, 0.016 inch thick.
   2. Fabricate continuous flashings in sections 96 inches long minimum, but not exceeding 12 feet. Provide splice plates at joints of formed, smooth metal flashing.
   3. Fabricate through-wall flashing with snap-lock receiver on exterior face where indicated to receive counter Flashing.
4. Fabricate through-wall flashing with drip edge where indicated. Fabricate by extending flashing 1/2 inch out from wall, with outer edge bent down 30 degrees and hemmed.

5. Metal Drip Edge: Fabricate from stainless steel. Extend at least 3 inches into wall and 1/2 inch out from wall, with outer edge bent down 30 degrees and hemmed.


C. Flexible Flashing: Use one of the following unless otherwise indicated:

1. Non-asphaltic, Stainless-Steel-Laminated Flashing: 7-oz./sq. ft., No. 316 stainless-steel sheet bonded on one side to glass-fiber cloth or polymeric fabric.
   a. Products: Subject to compliance with requirements, provide one of the following:
      1) Hohmann & Barnard, Inc.; Mighty-Flash Stainless Steel Fabric Flashing.
      2) York Manufacturing, Inc.; Multi-Flash SS.

   a. Products: Subject to compliance with requirements, provide one of the following:
      2) York Manufacturing, Inc.; York 316

D. Accessories: Provide preformed corners, end dams, other special shapes, and seaming materials produced by flashing manufacturer.

E. Application: Unless otherwise indicated, use the following:

1. Where flashing is indicated to receive counterflashing, use metal flashing.
2. Where flashing is indicated to be turned down at or beyond the wall face, use metal flashing.
3. Where flashing is partly exposed and is indicated to terminate at the wall face, use metal flashing with a built-in metal drip edge, or flexible flashing with manufactured metal drip edge.
4. Where flashing is fully concealed, use metal flashing or flexible flashing.

F. Solder and Sealants for Sheet Metal Flashings: As specified in Division 07 Section "Sheet Metal Flashing and Trim."

1. Solder for Stainless Steel: ASTM B 32, Grade Sn60, with phosphoric acid flux of type recommended by stainless-steel sheet manufacturer.
2. Elastomeric Sealant: ASTM C 920, chemically curing silicone sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

G. Adhesives, Primers, and Seam Tapes for Flashings: Flashing manufacturer's standard products or products recommended by flashing manufacturer for bonding flashing sheets to each other and to substrates.

H. Termination Bars for Flexible Flashing: Stainless steel bars 1/8 inch by 1 inch.

2.8 MISCELLANEOUS MASONRY ACCESSORIES

A. Cement Backer Board: Refer to Section 061600 "Sheathing."
B. Rigid Insulation: Semi-rigid mineral wool board complying with Section 072100 "Thermal Insulation" as part of NFPA 285 compliant assembly.

C. Thermal Spacer Composite Support System: Refer to Section 072100 "Thermal Insulation."

D. Weather-Resistive-Barrier (WRB): Fluid-applied air barrier complying with Section 072726 "Membrane Air Barriers" as part of NFPA 285 compliant assembly.

E. Compressible Filler: Premolded filler strips complying with ASTM D 1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from urethane or PVC.

F. Preformed Control-Joint Gaskets: Made from styrene-butadiene-rubber compound, complying with ASTM D 2000, Designation M2AA-805 or PVC, complying with ASTM D 2287, Type PVC-65406 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.

G. Bond-Breaker Strips: Asphalt-saturated, organic roofing felt complying with ASTM D 226, Type I (No. 15 asphalt felt).

   1. Paper Backing: FS UU-B-790a, Type I, Grade D, Style 2 vapor-permeable paper.

I. Lath Attachment Devices: Material and type required by ASTM C1063 for installations indicated.

J. Weep/Vent Products: Use one of the following unless otherwise indicated:
   1. Mesh Weep/Vent: Free-draining mesh; made from polyethylene strands, full height and width of head joint and depth 1/8 inch less than depth of outer wythe; in color selected from manufacturer's standard.
      a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
         1) Advance Building Products Inc.; Mortar Break Weep Mesh.
         2) Archovations, Inc.; CavClear Weep Vents.
         3) Mortar net USA, Ltd.; Mortar Net Weep Vents.
   2. Vinyl Weep/Vent: Units made from flexible PVC, designed to fit into a head joint and consisting of a louvered vertical leg, flexible wings to seal against ends of masonry units, and a top flap to keep mortar out of the head joint; in color selected by Architect.
      a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
         1) Hohmann & Barnard, Inc.; #343 Weep Hole.
         2) Williams Products, Inc.; Williams-Goodco Brick Vent.
         3) Wire-Bond; Louvered Weep Holes.

K. Cavity Drainage Material: Free-draining mesh, made from polymer strands that will not degrade within the wall cavity.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Mortar Net USA, Ltd.; Mortar Net.
   2. Provide one of the following configurations:
2.9 MASONRY SEALER AND GRAFFITI CONTROL

A. Masonry Sealer and Graffiti Control: Manufacturer's clear, penetrating, solvent-based silicone elastomer formulated to weatherproof brick materials and protect treated surfaces from repeated graffiti attacks without altering the natural appearance.

1. Product: Subject to compliance with requirements, provide the following, or Architect approved equal:
   a. PROSOCO, Inc.; Sure Klean Weather Seal Blok-Guard & Graffiti Control

2.10 MASONRY CLEANERS

A. Proprietary Acidic Cleaner: Manufacturer's standard-strength cleaner designed for removing mortar/grout stains, efflorescence, and other new construction stains from new masonry without discoloring or damaging masonry surfaces. Use product expressly approved for intended use by cleaner manufacturer and manufacturer of masonry units being cleaned.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. PROSOCO, Inc.

2.11 MORTAR MIXES

A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures, unless otherwise indicated.

1. Do not use calcium chloride in mortar.
2. Use portland cement-lime mix, or preblended mix, unless otherwise indicated.
3. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.

B. Mortar for Unit Masonry: Comply with ASTM C 270, Proportion Specification. Provide the following types of Portland-cement-sand mortar:

1. Type N.

C. Preblended, Portland Cement-Lime Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.

D. Preblended, Dry Mortar Thinset Adhesive and Moisture Control Mixes: Mix according to manufacturer's instructions at the Project site.

E. Preblended Pointing Mortar Mix: Mix according to manufacturer's instructions at the Project site.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
   1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean surfaces thoroughly prior to installation. All surfaces including, but not limited to metal panel and back face of thin brick must be free of water, snow, dirt, mud, oil and other foreign materials prior to application.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

C. Trim or flash in place per manufacturer's details and BIA Technical Note 28C on Thin Brick Veneer.

D. Protect the tops of all uncompleted walls to prevent water entry.

3.3 LINTELS

A. Install steel lintels where indicated.

B. Provide minimum bearing of 8 inches at each jamb unless otherwise indicated.

3.4 FLASHING, WEEP HOLES, AND VENTS

A. General: Install embedded flashing and weep holes in masonry at shelf angles, lintels, ledges, other obstructions to downward flow of water in wall, and where indicated. Install vents at shelf angles, ledges, and other obstructions to upward flow of air in cavities, and where indicated.

B. Install flashing as follows unless otherwise indicated:
   1. Extend flashing through veneer, across airspace behind veneer, and up face of sheathing at least 8 inches. Fasten upper edge of flexible flashing through sheathing to metal stud backup with termination bar; seal top edge of termination bar. Lap water-resistant barrier at least 4 inches over top edge of flashings.
   2. At lintels and shelf angles, extend flashing a minimum of 6 inches into masonry at each end. At heads and sills, extend flashing 6 inches at ends and turn up not less than 2 inches to form end dams.
   3. Seal laps in flashing with elastomeric sealant complying with requirements in Section 079200 "Joint Sealants" for application indicated.
4. Where shown or required, install metal drip edges beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch back from outside face of wall, and adhere flexible flashing to top of metal drip edge.

5. Install metal flashing termination beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch back from outside face of wall, and adhere flexible flashing to top of metal flashing termination.

6. Cut flexible flashing off flush with face of wall after masonry wall construction is completed.

C. Install reglets and nailers for flashing and other related construction where they are shown to be built into masonry.

D. Lap flashing ends a minimum of 3 inches.

E. Seal vertical and horizontal legs of all flashing laps with compatible lap sealant.

F. Lap water-resistive barrier over top of flashing.

G. Mechanically attach flashing, and tape and seal top edge of flashing according to manufacturer's instructions to surface of water-resistive barrier over backing in such a manner as to prevent moisture from entering the wall or to redirect water to the exterior.

H. Turn up the ends of discontinuous (e.g., head, sill and stepped) flashings to form end dams or extend not less than 4 inches beyond edges of openings.

I. Extend flashing through wall with at least 1/4 inch exposed to form a drip.

J. Install weep holes in veneers in head joints of first course of masonry immediately above embedded flashing.

1. Use specified weep/vent products to form weep holes.
2. Use wicking material to form weep holes above flashing under brick sills. Turn wicking down at lip of sill to be as inconspicuous as possible.
3. Space weep holes 24 inches o.c. unless otherwise indicated.
4. Space weep holes formed from wicking material 16 inches o.c.
5. Cover cavity side of weep holes with plastic insect screening at cavities insulated with loose-fill insulation.
6. Trim wicking material flush with outside face of wall after mortar has set.

K. Place cavity drainage material in airspace behind veneers to comply with configuration requirements for cavity drainage material in "Miscellaneous Masonry Accessories" Article.

3.5 INSTALLATION, GENERAL

A. Leave openings for equipment to be installed before completing masonry. After installing equipment, complete masonry to match the construction immediately adjacent to opening.

B. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.

C. Select and arrange units for exposed unit masonry to produce a uniform blend of colors and textures. Mix units from several pallets or cubes as they are placed.
D. Wetting of Brick: Wet brick before laying if initial rate of absorption exceeds 30 g/30 sq. in. per minute when tested according to ASTM C 67. Allow units to absorb water so they are damp but not wet at time of laying.

3.6 EXPANSION JOINTS

A. General: Install expansion-joint materials in unit masonry as masonry progresses. Do not allow materials to span expansion joints without provision to allow for in-plane wall or partition movement.

B. Form expansion joints as follows:
   1. Build flanges of metal expansion strips into masonry. Lap each joint 4 inches in direction of water flow. Seal joints below grade and at junctures with horizontal expansion joints if any.
   2. Build flanges of factory-fabricated, expansion-joint units into masonry.
   3. Build in compressible joint fillers where indicated.
   4. Form open joint full depth of brick wythe and of width indicated, but not less than 1/2 inch for installation of sealant and backer rod specified in Section 079200 "Joint Sealants."

C. Install metal expansion strips in sealant joints at locations indicated. Build flanges of expansion strips into masonry by embedding in mortar between stone masonry and backup wythe. Lap each joint 4 inches in direction of water flow. Seal joints below grade and at junctures with horizontal expansion joints if any.

D. Provide horizontal, pressure-relieving joints by either leaving an airspace or inserting a compressible filler of width required for installing sealant and backer rod specified in Section 079200 - Joint Sealants, but not less than 3/8 inch.

E. Locate horizontal, pressure-relieving joints beneath shelf angles supporting masonry.

3.7 LAYING MASONRY WALLS

A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.

B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in bond pattern indicated on Drawings; do not use units with less-than-nominal 4-inch horizontal face dimensions at corners or jambs.

C. Stopping and Resuming Work: Stop work by stepping back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, and wet brick if required before laying fresh masonry.

D. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.

E. Perform necessary field cutting and trimming as masonry is set.

F. Arrange masonry with color and size variations uniformly dispersed for an evenly blended appearance.
G. Set masonry to comply with requirements indicated on Drawings. Install supports, fasteners, and other attachments indicated or necessary to secure masonry in place. Set masonry accurately in locations indicated, with edges and faces aligned according to established relationships and indicated tolerances.

H. Maintain uniform joint widths. Lay walls with joints not less than 3/8 inch at narrowest points or more than 1/2 inch at widest points.

I. Provide sealant joints of widths and at locations indicated.
   1. Keep sealant joints free of mortar and other rigid materials.
   2. Sealing joints are specified in Section 079200 "Joint Sealants."

3.8 MORTAR BEDDING AND JOINTING

A. General: Use either Portland cement-lime-sand mortar or prepackaged Portland cement-lime mortar mix.

B. Lay solid masonry units with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not deeply furrow bed joints or slush head joints.

C. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.

3.9 TOLERANCES

A. Dimensions and Locations of Elements:
   1. For dimensions in cross section or elevation, do not vary by more than plus 1/2 inch or minus 1/4 inch.
   2. For location of elements in plan, do not vary from that indicated by more than plus or minus 1/2 inch.
   3. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4 inch in a story height or 1/2 inch total.

B. Lines and Levels:
   1. For bed joints and top surfaces of bearing walls, do not vary from level by more than 1/4 inch in 10 feet, or 1/2 inch maximum.
   2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 feet, 1/4 inch in 20 feet, or 1/2 inch maximum.
   3. For vertical lines and surfaces, do not vary from plumb by more than 1/4 inch in 10 feet, 3/8 inch in 20 feet, or 1/2 inch maximum.
   4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 feet, 1/4 inch in 20 feet, or 1/2 inch maximum.
   5. For lines and surfaces, do not vary from straight by more than 1/4 inch in 10 feet, 3/8 inch in 20 feet, or 1/2 inch maximum.
   6. For vertical alignment of exposed head joints, do not vary from plumb by more than 1/4 inch in 10 feet, or 1/2 inch maximum.
   7. For faces of adjacent exposed masonry units, do not vary from flush alignment by more than 1/16 inch except due to warpage of masonry units within tolerances specified for warpage of units.
C. Joints:
   1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch, with a maximum thickness limited to 1/2 inch.
   2. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch.
   3. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch or minus 1/4 inch.
   4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch. Do not vary from adjacent bed-joint and head-joint thicknesses by more than 1/8 inch.
   5. For exposed bed joints and head joints of stacked bond, do not vary from a straight line by more than 1/16 inch from one masonry unit to the next.

3.10 ANCHORED MASONRY VENEERS
A. Anchor masonry veneers to wall framing with seismic masonry-veneer anchors to comply with the following requirements:
   1. Fasten screw-attached and seismic anchors through insulation and sheathing to wall framing to metal stud backup with metal fasteners of type indicated. Install in accordance with manufacturer.
   2. Embed tie sections in masonry joints.
   3. Locate anchor sections to allow maximum vertical differential movement of ties up and down.
   4. Space anchors as indicated, but not more than 15 inches o.c. vertically and 16 inches o.c. horizontally, with not less than one anchor for each 2 sq. ft. of wall area. Install additional anchors within 12 inches of openings and at intervals, not exceeding 8 inches, around perimeter.
B. Provide not less than 1 inch of airspace between back of masonry veneer and face of insulation.
   1. Keep airspace clean of mortar droppings and other materials during construction. Bevel beds away from airspace, to minimize mortar protrusions into airspace. Do not attempt to trowel or remove mortar fins protruding into airspace.

3.11 ADHERED THIN BRICK VENEER
A. General: Use either dry Portland cement-lime mortar mix or prepackaged thinset mortar adhesive over cement backer board.
B. Cement Board: Install cement backer boards over thermal spacers and continuous insulation in accordance with Section 061600 "Sheathing" and Section 072100 "Thermal Insulation."
C. Portland Cement-Lime Mortar:
   1. Install paper-backed metal lath over water-resistive barrier on cement backer board to comply with ASTM C1063.
   2. Install scratch coat over metal lath 3/8 inch (10 mm) thick to comply with ASTM C926.
   3. Coat backs of brick units and face of scratch coat with cement-paste bond coat, then butter both surfaces with setting mortar. Use sufficient setting mortar, so a slight excess will be forced out the edges of stone units as they are set. Tap units into place, completely filling space between units and scratch coat.
D. Install mortar adhesive in accordance with manufacturer's instructions.
2. Horizontal, Soffits: Install thin brick with thin-brick mortar adhesive over cement backer board.
3. Key thin-set adhesive mortar materials thoroughly into substrate. Comb on additional mortar with the notched side of a 1/4-inch by 3/8-inch notched trowel.

E. Coat backs of thin brick units with thin-set adhesive mortar coat. Use sufficient mortar, so a slight excess will be forced out the edges of brick units as they are set. Tap units into place, completely filling space between units and backup.

F. Discard mortar after two hours or when too stiff to work. Retempering within two hours is permitted, but may contribute to mortar color variation.

G. Do not fill movement joints to receive sealant.

3.12 POINTING
A. Prepare brick-joint surfaces for pointing with mortar by removing dust and mortar particles. Where setting mortar was removed to depths greater than surrounding areas, apply pointing mortar in layers not more than 3/8 inch deep until a uniform depth is formed.

B. Point brick joints by placing and compacting pointing mortar in layers of not more than 3/8 inch deep. Compact each layer thoroughly, and allow it to become thumbprint hard before applying next layer.

C. Tool joints, when pointing mortar is thumbprint hard, with a smooth jointing tool to produce the following joint profile:
   1. Joint Profile: Match campus standard, unless otherwise indicated.

3.13 FIELD QUALITY CONTROL
A. Testing and Inspecting: Owner will engage special inspectors to perform tests and inspections and prepare reports. Allow inspectors access to scaffolding and work areas as needed to perform tests and inspections. Retesting of materials that fail to comply with specified requirements shall be done at Contractor's expense.

B. Inspections: Special inspections according to Level B in TMS 402/ACI 530/ASCE 5.
   1. Begin masonry construction only after inspectors have verified proportions of site-prepared mortar.

C. Testing Prior to Construction: One set of tests.

D. Clay Masonry Unit Test: For each type of unit provided, according to ASTM C 67 for compressive strength.

E. Mortar Aggregate Ratio Test (Proportion Specification): For each mix provided, according to ASTM C 780.

F. Mortar Test (Property Specification): For each mix provided, according to ASTM C 780. Test mortar for mortar air content and compressive strength.
G. Water-Spray Test: Test area of assembly [shown on Drawings] [as directed by Architect] <Insert area> for water penetration according to AAMA 501.2. Test assembly after installation of composite support system but prior to installation of cement backer board at thin brick applications in accordance with Section 072726 "Membrane Air Barriers."

3.14 REPAIRING AND CLEANING

A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.

B. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooiling joints.

C. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:
   1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
   2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before proceeding with cleaning of masonry.
   3. Protect adjacent nonmasonry surfaces from contact with cleaner by covering them with liquid strippable masking agent or polyethylene film and waterproof masking tape.
   4. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
   6. Clean masonry with a proprietary acidic cleaner applied according to manufacturer's written instructions.

3.15 WATER REPELLENT AND GRAFFITI CONTROL

A. Application:
   1. Before applying, read “Preparation” and “Safety Information” sections in the Manufacturer’s Product Data Sheet. Refer to the Product Data Sheet for additional information about application of water repellants and graffiti control. Do not dilute or alter.
   2. Apply products in accordance with manufacturer’s written instructions at a rate and thickness to match approved mockup Sample and in a manner that does not alter finish appearance of masonry.

B. Dense, Smooth Surfaces:
   1. Apply enough in a single saturating application to completely wet the surface without creating drips, puddles or rundown. Brush out or back roll all runs and drips for uniform appearance. Do not over apply. Over application may cause unacceptable color change. One application is normally enough. Always test for application rate.

C. Protect treated surfaces from rain for a minimum of 6 hours after application.

D. Demonstrate graffiti removal to Owner’s representative.
3.16 MASONRY WASTE DISPOSAL

A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property. At completion of unit masonry work, remove from Project site.

B. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above or recycled, and other masonry waste, and legally dispose of off Owner’s property in accordance with Section 017419 “Construction Waste Management and Disposal.”

END OF SECTION
SECTION 050413 - COMMON SUBMITTAL REQUIREMENTS FOR METALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:

1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.

1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:

1. Shop Drawings.
2. Product Data.
3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
   1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering

1. Number submittals as described below to assist tracking.

2. Number each submittal in the format nnnnnn-nn.

   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.

   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.

   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.

   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.

   e. Examples:


3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:

   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 050525 - POST-INSTALLED CONCRETE ANCHORS

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Post-installed mechanical anchors in concrete, including:
      a. Wedge-type expansion anchors approved for use for seismic applications in cracked and uncracked concrete.
      b. Screw-type drilled-in anchors approved for use for seismic applications in cracked and uncracked concrete.
   2. Post-installed adhesive anchors in concrete, approved for use for seismic applications in cracked and uncracked concrete.

B. Related Sections:

1.2 REFERENCES


1.3 DEFINITIONS

A. Nominal Embedment Depth: Minimum length from concrete surface to end of anchor following completion of anchor installation. For wedge-type anchors, nominal embedment depth shall be measured following application of installation torque.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Division 01, "Submittal Procedures".
   1. Manufacturer's product data.
   2. Manufacturer’s installation instructions.
   3. ICC-ES or IAPMO-ES Evaluation Reports.

1.5 QUALITY ASSURANCE

A. Certifications: Anchors shall have an active ICC-ES or IAPMO-ES Evaluation Report in accordance with the following ICC-ES Acceptance Criteria:
   1. Mechanical Anchors in Concrete: Acceptance Criteria for Mechanical Anchors in Concrete Elements (AC 193).

PART 2 – PRODUCTS

2.1 MECHANICAL ANCHORS

A. General: Anchors shall be tested and approved for use in cracked and uncracked concrete in accordance with ICC-ES AC 193.

1. Anchors installed through underside of steel deck shall be tested and approved for installation through the soffit of concrete-filled metal deck assemblies in accordance with ICC-ES AC 193.

B. Acceptable Products: Where anchor manufacturer and product are indicated on Drawings, provide designated product.

1. Contractor shall be allowed to substitute products of other manufacturer's, subject to demonstrating equivalent tension and shear strength to specified anchor, under project installation conditions. Product substitutions are subject to DSA review and approval, submitted by Architect as a SSC per IR A-6.

2. Where anchor design is prepared by Trade Subcontractor's Engineer, use product designated by Trade Subcontractor's Engineer, subject to meeting requirements of this Section.

C. Wedge Anchors: Wedge type, torque-controlled expansion anchors approved for use in cracked and uncracked concrete. Size and nominal embedment depth as indicated on Drawings.

1. Material: Unless otherwise indicated on the Drawings, provide carbon steel anchors with zinc plating in accordance with ASTM B633, SC1, Type III. As indicated on the Drawings, provide AISI Type 304 or Type 316 stainless steel anchors with manufacturers matching nut and washer.

2. Acceptable Products: Where anchor product and manufacturer are not indicated on Drawings or designated by Trade Subcontractor's Engineer, provide one of the following:
   a. Kwik Bolt TZ, by Hilti, Inc. per ICC ESR 1917.

D. Screw Anchors: Hardened steel, screw-type anchors or rod hangers approved for use in cracked and uncracked concrete. Diameter and nominal embedment depth as indicated on Drawings.

1. Limitations: Anchors shall be used in dry interior environments only.

2. Material: Case hardened low carbon steel, with zinc plating in accordance with ASTM B633, SC1, Type III.

3. Acceptable Products: Where anchor product and manufacturer are not indicated on Drawings or designated by Trade Subcontractor's Engineer, provide one of the following:
   a. Kwik HUS-EZ screw anchor and HUS-EZ1 rod hanger, by Hilti per ICC ESR 3027

2.2 ADHESIVE ANCHORS

A. Adhesive Anchors: Threaded steel rod or inserts complete with nuts and washers, epoxy adhesive injection system, and manufacturer’s installation instructions.
B. General: Anchors shall be tested and approved for use to resist seismic forces (IBC Seismic Design Categories A to F) in cracked and uncracked concrete in accordance with ICC-ES AC 308.

C. Epoxy Adhesive: Two-component, 100% solids, structural epoxy conforming to ASTM C881, Type IV; Grade 3; prepackaged in cartridges for manually or pneumatically operated caulking gun and automatically mixed at nozzle.
   1. Where anchor manufacturer and product are indicated on Drawings, provide designated product.
   2. Contractor shall be allowed to substitute products of other manufacturer's, subject to demonstrating equivalent tension and shear strength to specified anchor, under project installation conditions.
   3. Where anchor design is prepared by Trade Subcontractor's Engineer, use product designated by Trade Subcontractor's Engineer, subject to meeting requirements of this Section.
   4. Acceptable Products: Where anchor product and manufacturer are not indicated on Drawings or designated by Trade Subcontractor's Engineer, provide one of the following:
      a. HIT RE500 V3 Epoxy Adhesive Anchoring System, by Hilti, Inc. (ICC ESR-3814)
      b. Set-XP Epoxy Adhesive, by Simpson Strong-Tie Co. (ICC ESR-2508)

D. Acrylic Adhesive: Hybrid Adhesive: Two-component, hybrid adhesive prepackaged in cartridges for manually or pneumatically operated caulking gun and automatically mixed at nozzle. Approved for use in cracked and uncracked concrete in accordance with ICC ES AC308 or ACI 355.4, as demonstrated by an active ICC or IAPMO Evaluation Service Report.
   1. Acceptable Products: Where anchor product and manufacturer are not indicated on Drawings or designated by Trade Subcontractor's Engineer, provide one of the following:
      a. HIT -HY 200 Adhesive, Hilti Inc. ICC ESR 3187
      b. AT-XP Adhesive, Simpson Strong-Tie Co UES ESR 0263

E. Threaded Rod:
   1. Material: Unless otherwise indicated on the Drawings, furnish carbon steel threaded rods conforming to ASTM A36 or ASTM A193 Type B7. As indicated on the Drawings, provide Type 304 or Type 316 stainless steel anchors with manufacturers matching nut and washer.
   2. Finish: Furnish carbon steel rods with zinc plating in accordance with ASTM B633, SC1, Type III at dry interior locations. Furnish carbon steel rods with hot-dipped galvanized coating complying with ASTM A153 at exterior and damp interior locations.

PART 3 – EXECUTION

3.1 INSTALLATION

A. General: Install anchors in conformance with manufacturer's written instructions.

B. Examination:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Notify Owner's Representative for clarification where reinforcing steel or other embedded items require relocation of anchors or cutting of reinforcement.
2. Notify Owner's Representative for clarification where anchors appear to be located too close to edge of concrete, in particular where edge is not shown on Drawing detail.

3. Notify Owner's Representative for clarification where concrete thickness is inadequate to achieve specified anchor embedment. Minimum concrete thickness shall allow for specified embedment, plus one anchor diameter allowance for overdrilling, plus 3/4 inch minimum cover from end of hole to concrete surface.

C. Drilling:
1. Do not drill holes in concrete mix has achieved full design strength.
2. Drill holes with rotary impact hammer drills using carbide-tipped bits with diameter as recommended by anchor manufacturer. Reduce impact as hole approaches concrete surface as necessary to prevent cracking and spalling. Use core bits only with approval of Owner's Representative and only for mechanical anchors.
3. Holes shall be drilled perpendicular to the concrete surface, unless otherwise shown on Drawings. Anchors shall be drilled to within 5 percent of specified alignment.
4. Exercise care in drilling to avoid damaging existing reinforcing, conduits and other embedded items.

D. Wedge Anchors:
1. Drill holes designated nominal embedment depth plus one anchor diameter minimum. End of hole shall be 3/4 inch minimum clear from concrete surface.
2. Remove dust and debris with pressurized air, in accordance with manufacturer's instructions.
3. Set anchors to designated nominal embedment depth, plus an allowance for withdrawal during torque tightening.
4. Tighten using a torque wrench to manufacturer's recommended installation torque. Following attainment of 10% of recommended torque, achieve 100% of designated torque within 5 or fewer turns of the nut. If torque is not achieved, the anchor shall be removed and replaced unless otherwise directed by the Owner's Representative.

E. Screw Anchors:
1. Take particular care to achieve proper hole diameter. Use only sharp bits with diameter recommended by manufacturer. Use drilling equipment and methods to prevent enlargement of holes by wobble.
2. Remove dust and debris with pressurized air, in accordance with manufacturer's instructions.
3. Install the anchor in accordance with manufacturer's instructions with an impact wrench. Take care not to overtighten anchor; note that manufacturer's maximum installation torque is not the torque intended to be achieved during proper installation.

F. Adhesive Anchors:
1. Drill holes to diameter recommended by manufacturer with rotary impact hammer drills using carbide-tipped bits; core bits shall not be permitted.
2. Thoroughly clean holes by brushing and blowing with compressed air in accordance with manufacturer's instructions. Clean immediately prior to anchor installation under observation of Special Inspector.
3. Inject adhesive into holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive. Follow manufacturer recommendations to ensure proper mixing of adhesive components. Sufficient adhesive shall be injected in the hole to ensure that the annular gap is filled to the surface. Remove excess adhesive from the surface. Shim anchors with suitable device to center the anchor in the hole.
4. Do not disturb or load anchors before manufacturer specified cure time has elapsed.
3.2 REPAIR OF DEFECTIVE WORK

A. Remove and replace misplaced or malfunctioning anchors. Fill empty anchor holes and patch failed anchor locations with high-strength non-shrink, nonmetallic grout. Anchors that fail to meet proof load or installation torque requirements shall be regarded as malfunctioning.

3.3 FIELD QUALITY CONTROL

A. Testing Agency will:

1. Review manufacturer's recommended installation and inspection procedures, as contained in Evaluation Service Report.

2. Special Inspect installation for conformance with Contract Documents, manufacturer's recommendations, and requirements of the applicable ES report. Verify that anchors are being installed by trained installers.
   a. Periodically inspect installation of mechanical anchors.
   b. Continuously inspect installation of adhesive anchors during hole cleaning and anchor installation.

3. Test anchors in accordance with requirements of CBC Section 1910A.5, including testing frequency and method for adhesive anchors.
   a. Test Loads: As shown on Drawings, or as otherwise designated by Owner’s Representative, in conformance with test load requirements CBC Section 1910A.5.4.
   b. Testing Frequency, Structural Applications: 100 percent, except frequency can be reduced in accordance with CBC Section 1910A.5.3.
   c. Testing Frequency, Equipment and Component Anchorage: 50 percent or alternate bolts in a group, including at least one-half of the anchors in each group shall be tested.

END OF SECTION
SECTION 051200 - STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Structural steel framing, steel lintels, shelf angles, embedded plates, open web joist bearing plates, steel beam bearing plates, slide bearings at expansion joints, roof opening frames, mechanical equipment support frames and other items defined as structural steel.
   2. Shear stud connectors, deformed bar anchors, anchor rods, expansion bolts and other incidental items of structural steel required to be built into concrete or masonry and attached to the structural frame.
   4. Erection of structural steel.
   5. Welding of reinforcing supplied by Section 03 20 00 "Concrete Reinforcing".
   6. Grout below steel bearing and base plates.

B. Related Sections:
   1. Section 01400 "Quality Control Requirements" for independent testing agency procedures and administrative requirements.
   2. Section 051213 "Architecturally Exposed Structural Steel Framing" for additional requirements for architecturally exposed structural steel.
   3. Section 053100 "Steel Decking" for field installation of shear connectors through deck.
   4. Section 055000 "Metal Fabrications" for miscellaneous steel fabrications and other metal items not defined as structural steel.
   5. Division 05 "Metal Stairs."
   6. Section 099600 "High-Performance Coatings" for surface-preparation and priming requirements at high-performance coatings.

1.2 REFERENCES

D. AISC Specification for Structural Joints Using ASTM A325 or A490 Bolts.
E. AWS D1.1: Structural Welding Code - Steel.
F. AWS D1.4: Structural Welding Code - Reinforcing Steel.
G. AWS D1.8: Structural Welding Code – Seismic Supplement
H. SSPC: The Society for Protective Coatings.
1.3 DEFINITIONS

A. Structural Steel: Elements of structural-steel frame, as classified by AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

B. Seismic-Load-Resisting System: Elements of structural-steel frame designated as "SLRS" or along grid lines designated as "SLRS" on Drawings, including columns, beams, and braces and their connections.

C. Heavy Sections: Rolled and built-up sections as follows:
   1. Shapes included in ASTM A6/A6M with flanges thicker than 1-1/2 inches.
   2. Welded built-up members with plates thicker than 2 inches.
   3. Column base plates thicker than 2 inches.

D. Protected Zone: Structural members or portions of structural members indicated as "Protected Zone" on Drawings. Connections of structural and nonstructural elements to protected zones are limited.

E. Demand Critical Welds: Those welds, the failure of which would result in significant degradation of the strength and stiffness of the Seismic-Load-Resisting System and which are indicated as "Demand Critical" or "Seismic Critical" on Drawings.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. LEED Submittals:
   1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating cost for each product having recycled content.

C. Shop Drawings: Submit fabrication and erection drawings in accordance with Section 01 33 00. Show fabrication of structural-steel components. Before preparation of shop drawings and fabrication of materials affected by existing construction, field verify existing elevations, dimensions and conditions as shown on Contract Documents and report discrepancies to Architect for resolution. Submit all relevant drawings together so that review can be complete.
   1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
   2. Include embedment drawings.
   3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.
   4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical high-strength bolted connections.
   5. Indicate items to be galvanized, where required.
   6. Identify members and connections of the seismic-load-resisting system.
   7. Indicate locations and dimensions of protected zones.
   8. For each joint, identify demand critical welds including prequalified welded joint designation and welding process.
   9. Indicate all locations of SLRS where nondestructive testing is to be performed by Fabricator.
   10. Include welding access hole dimensions, surface profile and finish requirements.
   11. Indicate where weld tabs are to be removed.
D. Welding Procedure Specifications (WPSs) and Procedure Qualification Records (PQRs):
Provide according to AWS D1.1, "Structural Welding Code - Steel," for each welded joint qualified by testing, including the following:
1. Power source (constant current or constant voltage).
2. Electrode manufacturer and trade name, for demand critical welds.

1.5 INFORMATIONAL SUBMITTALS
A. Welding certificates.
B. Mill test reports for structural steel, including chemical and physical properties.

1.6 QUALITY ASSURANCE
A. Fabricator Qualifications: A fabricator experienced in fabricating structural steel similar to that indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to fabricate structural steel without delaying the Work.
   1. Fabricator shall participate in the AISC Quality Certification Program and be designated an AISC-Certified Plant, Category BU.
B. Installer Qualifications: An experienced installer who has completed structural steel work similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
   1. Installer shall participate in the AISC Quality Certification Program and be designated an AISC-Certified Erector, Category ACSE.
C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel."
   1. Welders and welding operators performing work on bottom-flange, demand-critical welds shall pass the supplemental welder qualification testing, as required by AWS D1.8. FCAW-S and FCAW-G shall be considered separate processes for welding personnel qualification.
D. Comply with applicable provisions of the following specifications and documents:
   1. AISC 303.
   2. AISC 341 and AISC 341s1.
   3. AISC 360.
   4. RCSC's "Specification for Structural Joints Using ASTM A325 or A490 Bolts."

1.7 DELIVERY, STORAGE, AND HANDLING
A. Deliver materials to site at such intervals to ensure uninterrupted progress of work.
B. Deliver anchor rods and anchorage devices to be embedded in cast-in-place concrete or masonry in ample time so as to not delay work.
C. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.
1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.

D. Store fasteners in a protected place in sealed containers with manufacturer’s labels intact.
   1. Fasteners may be repackaged provided Owner’s testing and inspecting agency observes repackaging and seals containers.
   2. Only new and factory lubricated fasteners shall be used on the project. Fasteners that have become dry or rusty are not permitted.

E. Store welding electrodes in hermetically sealed containers. Electrodes exposed to the atmosphere for periods greater than those permitted shall be redried in accordance with AWS D1.1.

1.8 STRUCTURAL STEEL TO RECEIVE SFRM

A. Provide structural steel substrate to receive sprayed fire-resistive materials free of paint, lubricants, oils, dirt or other contaminants which would significantly impair adhesion of sprayed materials.

1.9 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers’ recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

PART 2 - PRODUCTS

2.1 STRUCTURAL-STEEL MATERIALS

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25%.

B. W-Shapes and WT cut from W-shapes: ASTM A992.

C. Channels, Angles and Miscellaneous Shapes: ASTM A36.

D. Plate and Bar: Per Drawings.

E. Cold-Formed Hollow Structural Sections: ASTM A500, Grade B, structural tubing.
F. Steel Pipe: ASTM A53, Type E or S, Grade B.

G. Welding Electrodes: Comply with AWS requirements, including requirements for welds in the Seismic Force Resisting System and Demand Critical welds.

2.2 BOLTS, CONNECTORS, AND ANCHORS

A. High-Strength Bolts, Nuts, and Washers: ASTM A325, Type 1, heavy-hex steel structural bolts or ASTM F1852 tension-control, bolt-nut-washer assemblies with splined ends; ASTM A563, Grade C, heavy-hex carbon-steel nuts; and ASTM F436, Type 1, hardened carbon-steel washers.
   1. Direct-Tension Indicators: ASTM F959, Type 325, compressible-washer type with plain finish.

B. High-Strength Bolts, Nuts, and Washers: ASTM A490, Type 1, heavy-hex steel structural bolts or ASTM F2280 tension-control, bolt-nut-washer assemblies with splined ends; ASTM A563, Grade DH, heavy-hex carbon-steel nuts; and ASTM F436, Type 1, hardened carbon-steel washers with plain finish.
   1. Direct-Tension Indicators: ASTM F959, Type 490, compressible-washer type with plain finish.

C. Shear Connectors: ASTM A108, Grades 1015 through 1020, headed-stud type, cold-finished carbon steel; AWS D1.1, Type B.

D. Anchor Rods: ASTM F1554, Grade 36
   2. Head: Form head with ASTM A563, Grade A, heavy hex nut. Lock against loosening with suitable jam nut.
   3. Plate Washers: ASTM A572 Grade 50. Provide steel plate of sufficient size to completely cover hole in baseplate; minimum thickness shall be 1/3 of bolt diameter.

E. High Strength Anchor Bolt Assembly:
   1. Anchor rod: ASTM F1554, Grade 105, with Supplementary Requirement S4, "Grades 55 and 105 Charpy Impact Requirements at +40 deg F." Mark exposed end in accordance with Supplementary Requirement S3, "Permanent Grade Identification".
   2. Head: Form head with round steel plate washer sandwiched between ASTM A194, Grade 2H, heavy hex nuts. Plate washer size shall be 3 times bolt diameter and thickness shall be 1/2 of the bolt diameter, unless otherwise designated.
   4. Washer: Provide steel plate washer of sufficient size to completely cover hole in baseplate; minimum thickness shall be 1/3 of bolt diameter.


G. Non-High-Strength Bolts, Nuts, and Washers: ASTM A307, Grade A.
H. Deformed Bar Anchors: ASTM A496 or ASTM A1064.

I. Clevises and Turnbuckles: Made from cold-finished carbon steel bars, ASTM A108, Grade 1035.

J. Eye Bolts and Nuts: Made from cold-finished carbon steel bars, ASTM A108, Grade 1030.


L. Hot Dip Galvanizing for Bolts and Similar Threaded Fasteners: ASTM A153.

2.3 PRIMER

A. Shop-Applied Primer for Steel to Receive High-Performance Coating (HPC): Coordinate with Section 09 96 00 - High-Performance Coatings.

B. Primer: Fabricator's standard lead- and chromate-free, nonasphaltic, rust-inhibiting primer complying with MPI#79 and compatible with topcoat.

C. Galvanizing Repair Paint: ASTM A780.

D. Coating for Steel in Contact with Earth: 3M SkotchKote 306, liquid epoxy, or approved equal.

2.4 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C1107, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.5 FABRICATION

A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate in accordance with reviewed shop drawings, AISC's "Code of Standard Practice for Steel Buildings and Bridges" and AISC 360.

1. Camber structural-steel members where indicated.
2. Fabricate beams with rolling camber up.
3. Identify high-strength structural steel according to ASTM A6 and maintain markings until structural steel has been erected.
4. Mark and match-mark materials for field assembly.
5. Clip angles, headed shear connectors or other components shown welded to top flanges of beams, except for end connections, shall be shipped loose for attachment in field.
6. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.

B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.

1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1.

C. Bolt Holes: Cut, drill, mechanically thermal cut, or punch standard bolt holes perpendicular to metal surfaces.
D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.

E. Cleaning: Clean and prepare steel surfaces that are to remain unpainted according to SSPC-SP 1, "Solvent Cleaning" or SSPC-SP 2, "Hand Tool Cleaning".

F. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1 and manufacturer's written instructions.

G. Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel members.
   1. Baseplate Holes: Cut, drill, mechanically thermal cut, or punch holes perpendicular to steel surfaces.
   2. Weld threaded nuts to framing and other specialty items indicated to receive other work.

H. Where lintel and soffit plates are indicated with edge flush with masonry, horizontal leg shall either terminate 1/4 inch short of masonry at jambs, or be notched at end extending into masonry to permit mortar joints across face. At beam and plate lintels spanning from jamb to jamb of opening, stop plate short of masonry. Where bearing of horizontal leg is required at opening jamb, notch lintel end to permit full 3/4 inch of mortar cover along face.

2.6 SHOP CONNECTIONS

A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A325 or A 490 Bolts" for type of bolt and type of joint specified.

B. Weld Connections: Comply with AWS D1.1 and AWS D1.8 for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
   1. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances in AISC 303 for mill material.

2.7 SHOP PRIMING

A. Shop prime steel surfaces unless otherwise noted. Do not shop prime the following:
   1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.
   2. Surfaces to be field welded.
   3. Surfaces to be high-strength bolted with slip-critical connections.
   4. Surfaces to receive sprayed fire-resistant materials applied fireproofing.
   5. Galvanized surfaces.

B. Shop prime steel surfaces concealed by interior building finish.

C. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:
   1. SSPC-SP 2, "Hand Tool Cleaning."
   2. SSPC-SP 3, "Power Tool Cleaning."
   3. SSPC-SP 7/NACE No. 4, "Brush-Off Blast Cleaning."
   4. SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
a. Provide at exposed structural steel surfaces.

D. Priming: Immediately after surface preparation, apply primer according to manufacturer’s written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

E. Priming at High-Performance Coatings: Comply with Section 09 96 00 "High-Performance Coatings."
   2. Apply shop primer in accordance with High-Performance Coating manufacturer’s instructions after surface preparation in compliance with primer manufacturer’s requirements. Maintain minimum coverage at joints, corners, edges and exposed surfaces.

2.8 GALVANIZING

A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A123.
   1. Fill vent and drain holes that will be exposed in the finished Work unless they will function as weep holes, by plugging with zinc solder and filing off smooth.

2.9 SOURCE QUALITY CONTROL

A. Testing and Inspection: Owner will engage qualified special inspectors in accordance with Section 01 45 33.
   1. Qualifications: The minimum category of special inspector required to perform services outlined below are noted by qualifications in parentheses. The definitions of the categories of special inspector are included in Section 01 45 33.

B. Coordinate with Independent Testing and Inspecting Agency employed by the Owner to perform shop quality control inspection and testing listed below:
   1. High Strength Bolting:
      a. General Requirements:
         1) On a periodic basis, verify bolting material conforms to specified ASTM standards.
         2) On a periodic basis, verify that the requirements for bolts, nuts, washers, paint, and installation/tightening standards are met.
         3) On a continuous basis, observe preinstallation testing and calibration procedures when such procedures are required by the installation method or in the Contract Documents.
            a) Where required by the installation method for slip-critical and pretensioned bolts, a representative sample of not fewer than three complete fastener assemblies of each combination of diameter, length, grade and lot to be used shall be tested in a tension calibrator to verify that the pretensioning method develops a pretension that is equal to or greater than 1.05 times the minimum pretension specified for the diameter and grade of bolt. Testing shall be conducted by Contractor and observed by the Special Inspector.
b. Slip-Critical and Pretensioned Bolts:
   1) On a periodic basis, visually inspect faying surfaces and bolt type for all slip-critical bolted connections for general conformance with the Contract Documents prior to bolting.
   2) On a periodic basis, verify that selected procedure is used to tighten bolts.
   3) On a continuous basis, observe bolt installation when the calibrated wrench method or turn-of-nut method without matchmarking is used.
   4) On a periodic basis, observe bolt installation when the turn-of-nut method with matchmarking, direct tension indicator, or tension-control (twist-off bolt) methods are used. Visually verify tightening of all bolts.

c. Snug-Tightened Bolts:
   1) On a periodic basis, visually inspect to verify that all plies of connected elements have been brought into contact, at 100% of connections.

2. Welding:
   a. Fillet Welds:
      1) On a periodic basis, visually inspect 100% of all fillet welds 5/16" or less, for size, length and quality, per AWS D1.1.
      2) On a continuous basis, inspect welding process for all multi-pass fillet welds and single-pass fillet welds larger than 5/16".

   b. Partial Penetration Welds:
      1) On a continuous basis, inspect welding process for all partial penetration groove welds.
      2) Test 100% of all partial penetration welds 5/16 inch and larger, using Ultrasonic Testing per AWS D1.1, Section 6. Test 25% of all partial penetration welds less than 5/16 inch, using Magnetic Particle Testing per ASTM E-709, performed on root pass and on finished weld.

   c. Full Penetration Welds:
      1) On a continuous basis, inspect welding process for all full penetration groove welds.
      2) Test 100% of all full penetration welds 5/16 inch and larger, using Ultrasonic Testing per AWS D1.1 Section 6. Test 25% of all full penetration welds less than 5/16 inch, using Magnetic Particle Testing per ASTM E-709, performed on root pass and on finished weld.
      3) Test 25% of all SLRS beam-to-column full penetration welds using Magnetic Particle Testing - Yoke Method per ASTM E-709 and AWS D1.8, performed on root pass and on finished weld.

3. Additional SLRS Testing and Inspection: In addition to the requirements above, inspection, testing and documentation for quality control and quality assurance for the seismic load resisting system shall be performed in accordance with the Quality Assurance Plan as defined in AISC 341-05, appendix Q. Additionally, welding inspection and nondestructive testing shall be performed in accordance with AWS D1.8 clause 7, including the following nondestructive testing work:
   a. Nondestructive testing of welds:
      1) In addition to the qualification requirements of Section 01 45 33, all Ultrasonic Testing technicians shall be certified by their employer for Flaw Detection in accordance with AWS D1.8, Annex F.
      2) Test 100% of all SLRS wide-flange member web k-areas using Magnetic Particle Testing where welding of doubler plates, continuity plates or stiffeners has been performed in the k-area.
3) Where weld tabs have been removed, test 100% of all weld ends using Magnetic Particle Testing. Exception: removed weld tabs at continuity plate welds need not be tested.

4) If a repair to a weld tab removal site is made by additional welding, test 100% of the repaired area and area immediately adjacent area to the repair using Magnetic Particle Testing.

5) If a repair to a weld access hole is made within a Protected Zone, test 100% of the access hole using Magnetic Particle Testing or Dye Penetrant Testing.

6) If a welding repair is performed within a Protected Zone, test 100% of the repair area using Magnetic Particle Testing.

C. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify, with steel Erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.

1. Prepare a certified survey of bearing surfaces, anchor rods, bearing plates, and other embedments showing dimensions, locations, angles, and elevations.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.

3.3 ERECTION

A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.


1. Set plates for structural members on wedges, shims, or setting nuts as required.
2. Weld plate washers to top of baseplate where indicated.
3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
4. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer’s written installation instructions for shrinkage-resistant grouts.
C. Maintain erection tolerances of structural steel within AISC's "Code of Standard Practice for Steel Buildings and Bridges."

D. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
   1. Level and plumb individual members of structure.
   2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.

E. Splice members only where indicated.

F. Do not use thermal cutting during erection unless approved by Structural Engineer of Record. Finish thermally cut sections within smoothness limits in AWS D1.1.

G. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.

H. Remove erection bolts on welded, Architecturally Exposed Structural Steel; fill holes with plug welds; and grind smooth at exposed surfaces.

I. Do not field cut openings through structural steel members for passage of conduit, pipes, or ducts without obtaining written permission from Structural Engineer of Record. Wherever permission is given, provide openings and additionally reinforce member as directed by Structural Engineer of Record.

J. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1 and manufacturer's written instructions.

3.4 FIELD CONNECTIONS

A. High-Strength Bolts: Install high strength bolts according to RCSC’s "Specification for Structural Joints Using ASTM A325 or A490 Bolts" and as indicated below for type of bolt and type of joint specified. If Twist-Off Tension-Control Bolts or Direct-Tension-Indicators are used, bolt assemblies shall be installed following recommendations of the manufacturer, and the following minimum requirements.
   1. ASTM F436, hardened carbon-steel washers shall be used at the following locations:
      a. To cover over-sized and slotted holes.
      b. Beveled washer at joint face with a slope greater than 1:20.
      c. Below the nut of a Twist-Off Tension-Control Bolt Assembly for Pretensioned, Slip-Critical and Bearing Joints when the spline is intended to be severed.
      d. Below the turned element when using a Calibrated Wrench Pretensioning method for Pretensioned and Slip-Critical Joints.
      e. At Pretensioned and Slip-Critical Joints with ASTM A490 bolts, under the bolt head or nut when bearing against connected material with a specified minimum yield strength less than 40 ksi.
   2. For Pretensioned and Slip-Critical Joints, assemblies shall be initially installed as a Snug-tightened joint. For Slip-Critical Joints with Tension-Control Bolt assemblies, the initial Snug-tightened joint shall also be accomplished without severing the splined end. If a
splined end is severed during this operation the bolt assembly shall be removed and replaced.

3. Snug-tightened condition shall bring the connected plies into firm contact. Compacting the joint to a snug-tight condition shall progress systematically from the most rigid part of the joint. Subsequent bolt tightening shall also progress systematically from the most rigid part of the joint.

4. Fastener components shall be protected from dirt and moisture in closed containers at the site of installation. Only as many fastener components as are anticipated to be installed during the work shift shall be taken from protected storage. Fastener components that are not incorporated into the work shall be returned to protected storage at the end of the work shift. Fastener components shall not be cleaned or modified from the as-delivered condition. Bolt assemblies that accumulate rust or dirt shall not be incorporated into the work.

B. Weld Connections: Comply with AWS D1.1 and AWS D1.8 for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.

2. Remove backing bars or runoff tabs where indicated, back gouge, and grind steel smooth.

3. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances in AISC’s "Code of Standard Practice for Steel Buildings and Bridges" for mill material.

3.5 FIELD QUALITY CONTROL

A. Testing and Inspection: Owner will engage qualified special inspectors.

B. Coordinate with independent testing and inspecting agency engaged by the Owner to perform field quality control inspection and testing.

1. Provide necessary scaffolding or temporary platforms required by testing agency in order to perform their work. Such scaffolding or platforms shall comply with safety regulations and shall be acceptable to testing agency.

C. High Strength Bolting:

1. General Requirements:
   a. On a periodic basis, verify bolting material conforms to specified ASTM standards.
   b. On a periodic basis, verify that the requirements for bolts, nuts, washers, paint, and installation/tightening standards are met.
   c. On a continuous basis, observe preinstallation testing and calibration procedures when such procedures are required by the installation method or in the Contract Documents.

1) Where required by the installation method for slip-critical and pretensioned bolts, a representative sample of not fewer than three complete fastener assemblies of each combination of diameter, length, grade and lot to be used shall be tested in a tension calibrator to verify that the pretensioning method develops a pretension that is equal to or greater than 1.05 times the minimum pretension specified for the diameter and grade of bolt. Testing shall be conducted by Contractor and observed by the Special Inspector.
2. Slip-Critical and Pretensioned Bolts:
   a. On a periodic basis, visually inspect faying surfaces and bolt type for all slip-critical bolted connections for general conformance with the Contract Documents prior to bolting.
   b. On a periodic basis, verify that selected procedure is used to tighten bolts.
   c. On a continuous basis, observe bolt installation when the calibrated wrench method or turn-of-nut method without matchmarking is used.
   d. On a periodic basis, observe bolt installation when the turn-of-nut method with matchmarking, direct tension indicator, or tension-control (twist-off bolt) methods are used. Visually verify tightening of all bolts.

3. Snug-Tightened Bolts:
   a. On a periodic basis, visually inspect to verify that all plies of connected elements have been brought into contact, at 100% of connections.

D. Welding:
1. Allow Testing Agency to visually inspect field welding of steel members in accordance with Section 6, Inspection of AWS Structural Welding Code. Correct work that is not approved and re-inspect until welds are acceptable to Testing Agency. Perform such additional inspecting and work at no additional cost to Owner.
2. Fillet Welds:
   a. On a periodic basis, visually inspect 100% of all fillet welds 5/16" or less, for size, length and quality, per AWS D1.1.
   b. On a continuous basis, inspect welding process for all multi-pass fillet welds and single-pass fillet welds larger than 5/16".
3. Partial Penetration Welds:
   a. On a continuous basis, inspect welding process for all partial penetration groove welds.
   b. Test 100% of all partial penetration welds 5/16 inch and larger, using Ultrasonic Testing per AWS D1.1, Section 6. Test 25% of all partial penetration welds less than 5/16 inch, using Magnetic Particle Testing per ASTM E-709, performed on root pass and on finished weld.
4. Full Penetration Welds:
   a. On a continuous basis, inspect welding process for all full penetration groove welds.
   b. Test 100% of all full penetration welds 5/16 inch and larger, using Ultrasonic Testing per AWS D1.1 Section 6. Test 25% of all full penetration welds less than 5/16 inch, using Magnetic Particle Testing per ASTM E-709, performed on root pass and on finished weld.
   c. Test 25% of all SLRS beam-to-column full penetration welds using Magnetic Particle Testing - Yoke Method per ASTM E-709 and AWS D1.8, performed on root pass and on finished weld.
5. Stud Shear Connector Welds:
   a. Verify all ceramic welding ferrules have been removed and visually inspect 100% of installed studs for full 360° flash. Alternatively, sound 100% of installed studs, for full penetration weld, using an 8 lb. maul.
   b. Test all questionable studs, not showing full 360° flash by bending studs to 15° from vertical, away from weld discontinuity, per AWS D1.1, Section 7.
c. Randomly test all other studs by bending to 15° from vertical as noted:
   1) Studs welded through deck: 15%.
   2) Studs welded to bare steel: 5%.

6. Miscellaneous Metals, Inserts and Prefabricated Components: Where integrity of the connections impact life safety or performance of the building structure, provide testing and inspection as for typical welds previously specified.

7. Procedures and Preparation:
   a. Verify qualifications of all welders as AWS certified.
   b. Verify manufacturer's certificates of compliance for weld filler materials.
   c. Verify proposed welding procedures and materials meet AWS requirements.
   d. On a periodic basis, verify adequate preparation of faying surfaces.
   e. On a periodic basis, verify preheat and interpass temperatures of steel, proper technique and sequence of welding, and cleaning and number of passes are provided as required.

E. Additional SLRS Testing and Inspection: In addition to the requirements above, inspection, testing and documentation for quality control and quality assurance for the seismic load resisting system shall be performed in accordance with the Quality Assurance Plan as defined in AISC 341-10, Section J. Additionally, welding inspection and nondestructive testing shall be performed in accordance with AWS D1.8 clause 7, including the following nondestructive testing work:

   1. Nondestructive testing of welds:
      a. In addition to the qualification requirements of Section 01 45 33, all Ultrasonic Testing technicians shall be certified by their employer for Flaw Detection in accordance with AWS D1.8, Annex F.
      b. Where weld tabs have been removed, test 100% of all weld ends using Magnetic Particle Testing. Exception: removed weld tabs at continuity plate welds need not be tested.
      c. If a repair to a weld tab removal site is made by additional welding, test 100% of the repaired area and area immediately adjacent area to the repair using Magnetic Particle Testing.
      d. If a repair to a weld access hole is made within a Protected Zone, test 100% of the access hole using Magnetic Particle Testing or Dye Penetrant Testing.
      e. If a welding repair is performed within a Protected Zone, test 100% of the repair area using Magnetic Particle Testing.

F. Protected Zones

   1. Verify location and extents of all Protected Zones with the Contract Documents.
   2. On a periodic basis, verify no holes and unapproved attachments have been placed in the Protected Zones.

G. Headed Shear Studs

   1. Verify stud quantities are as shown on Contract Documents.
   2. Verify stud placement layout and spacing requirements are as shown on Contract Documents.

H. Mechanical Fasteners (Misc.)

   1. Fasteners: Visually inspect specified size, spacing, embedment and location. See also Specification sections:
      a. 03 30 00 - Cast-In-Place Concrete.
b. 05 31 00 - Steel Decking.

c. 05 40 00 - Cold Formed Metal Framing.

I. Structural Configuration:

1. Submittals: On a periodic basis, verify mill test reports and other submitted
documentation, for compliance with Contract Documents.
   a. Materials: On a periodic basis, verify materials delivered to site comply with
      Contract Documents and approved shop drawings.
   b. Bolts.
   c. Electrodes.
   d. Mechanical Fasteners.
   e. Deck Gauge.

2. Detail Compatibility, on a periodic basis:
   a. Review project documents affecting integrity of the structure, including Contract
      Documents and pertinent submittals (approved shop drawings).
   b. Visit site, at intervals appropriate to the stage of construction, to perform review of
      the structure and visually confirm general compliance with the Contract Documents
      and pertinent submittals.
   c. Inspect the following to verify member orientation, configuration, type and size
      comply with details indicated on the Contract Documents and approved shop
      drawings:
         1) Bracing and stiffening members.
         2) Proper applications of joint details at connections for structural members.
         3) Other work critical to the integrity of the building structure.

J. Conventional Testing and Inspection Requirements:

1. High Strength Bolting:
   a. Bolt Material Test: Test a minimum of two bolts of each ASTM grade and diameter
      specified, for bolt hardness and tensile properties. (SNT-TC-1A).
   b. Fabrication and Erection Tolerances: Verify in-place structure satisfies specified
      tolerances.

K. If special inspection of fabricator's work is required, testing agency may test and inspect
structural steel at plant before shipment. Owner and SER reserve right to reject material not
complying with Contract Documents at any time before final acceptance.

L. Definitions:

   1. ASNT - The American Society for Non-destructive Testing.
   2. NDE - Non-destructive Evaluation.

M. Correct deficiencies in Work that test reports and inspections indicate does not comply with the
Contract Documents.

3.6 REPAIRS AND PROTECTION

A. Galvanized Surfaces: Clean areas where galvanizing is damaged or missing and repair
galvanizing to comply with ASTM A780.
B. Touchup Painting: Immediately after erection, clean exposed areas where primer is damaged or missing and paint with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

C. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.

END OF SECTION
SECTION 051213 - ARCHITECTURALLY EXPOSED STRUCTURAL STEEL (AESS)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes architecturally exposed structural-steel (AESS).
   1. Requirements in Section 051200 "Structural Steel Framing" apply to AESS as modified in this Section.
B. Related Requirements:
   1. Section 055000 "Metal Fabrications" for steel lintels and shelf angles not attached to structural-steel frame, miscellaneous steel fabrications, and other metal items not defined as structural steel.
   2. Section 057100 "Decorative Metal Stairs" for stairs with AESS finishing.
   3. Section 099600 "High-Performance Coatings" for surface preparation and priming requirements.

1.3 DEFINITIONS
A. AESS: Structural steel designated as "architecturally exposed structural steel" or "AESS" in the Contract Documents.

1.4 AESS GRADES
A. General: Comply with 2016 AISC "Code of Standard Practice for Steel Buildings and Bridges," Section 10, for a description of the grading categories used on the Drawings and as follows:
   1. AESS 3: Feature elements viewed at a distance less than 20 feet vertically and horizontally.

1.5 COORDINATION
A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

1.6 ACTION SUBMITTALS
A. Sustainable Design Submittals required by Section 01813 applicable to this Section.
B. Shop Drawings: Show fabrication of AESS components. Shop Drawings for structural steel may be used for AESS provided items of AESS are specifically identified and requirements below are met for AESS.

1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
2. Include embedment Drawings.
3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain. Indicate grinding, finish, and profile of welds.
4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical, high-strength bolted connections. Indicate orientation of bolt heads.
5. Indicate exposed surfaces and edges and surface preparation being used.
6. Indicate special tolerances and erection requirements.
7. Indicate tack welds, temporary braces, backing and fixtures used in fabrication, delivery, and erection.

C. Samples: Submit Samples of AESS to set minimum quality standards for exposed welds for Grades AESS-3 and better.

1. Two steel plates, 3/8 by 8 by 4 inches, with long edges joined by a groove weld and with weld ground smooth.
2. Steel plate, 3/8 by 8 by 8 inches, with one end of a short length of rectangular steel tube, 4 by 6 by 3/8 inches, welded to plate with a continuous fillet weld and with weld ground smooth and blended.
3. Round steel tube or pipe, minimum 8 inches in diameter, with end of another round steel tube or pipe, approximately 4 inches in diameter, welded to its side at a 45-degree angle with a continuous fillet weld and with weld ground smooth and blended.

1.7 QUALITY ASSURANCE

A. Fabricator Qualifications: A qualified fabricator that participates in the AISC Quality Certification Program and is designated an AISC-Certified Plant, Category STD, or is accredited by the IAS Fabricator Inspection Program for Structural Steel (AC 172).

1. In addition to the qualifications of steel fabricator listed in Section 051200, engage a steel fabricator experienced in fabricating AESS similar to that for this project and with a successful in-service performance.

B. Installer Qualifications: A qualified installer who participates in the AISC Quality Certification Program and is designated an AISC-Certified Erector, Category ACSE.

1. In addition to the qualifications of steel installer listed in Section 051200, engage a steel installer experienced in erecting AESS similar to that for this project and with a successful in-service performance.

C. Shop-Painting Applicators: Qualified according to AISC's Sophisticated Paint Endorsement P1, Endorsement P2, and Endorsement P3, or SSPC-QP 3, "Standard Procedure for Evaluating Qualifications of Shop Painting Applicators."

D. Shop Painting: Paint topcoats and other coatings to be applied over shop primers shall be compatible with shop primers.

E. Provide the following upon request:

1. Qualification Data: For Installer and fabricator.
2. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

F. Mockups: Build first-in-place mockups of AESS to set quality standards for fabrication and installation.
1. Build mockup of typical AESS column as shown on Drawings to be used as Project reference sample.
2. Coordinate high-performance coatings requirements with Section 099600 "High-Performance Coatings."
3. Obtain Architect's approval prior to commencement of remaining Work of this Section.
4. The expectations for the quality of workmanship, fabrication, finishing, and erection of AESS shall be as defined herein. The mockup shall be used as a basis for judgment of the as-built work.
5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
6. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Use special care in handling to prevent twisting, warping, nicking, bending, and other damage or distortions. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.
1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.
2. Use nylon tie-downs or chains with softeners to avoid damage to edges and surfaces of members.

1.9 FIELD CONDITIONS

A. Field Measurements: Where AESS is indicated to fit against other construction, verify actual dimensions by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 STRUCTURAL STEEL MATERIALS

A. Refer to Section 051200 "Structural Steel Framing" for structural steel to be finished as AESS.

2.2 DECORATIVE STEEL STAIRS AND RAILINGS

A. Refer to Section 057100 "Decorative Metal Stairs" and Section 057300 "Decorative Metal Railings" for stair and railing items to be finished as AESS.
2.3 BOLTS, CONNECTORS, AND ANCHORS

A. Tension-Control, High-Strength Bolt-Nut-Washer Assemblies: ASTM F 1852, Type 1, round-head assemblies, consisting of steel structural bolts with splined ends, heavy-hex carbon-steel nuts, and hardened carbon-steel washers.
   1. Finish: Mechanically deposited zinc coating.

B. Corrosion-Resisting (Weathering Steel), Tension-Control, High-Strength Bolt-Nut-Washer Assemblies: ASTM F 1852, Type 3, round-head assemblies, consisting of steel structural bolts with splined ends, heavy-hex carbon-steel nuts, and hardened carbon-steel washers.

2.4 FILLER


2.5 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Zinc-Rich Primer: Organic zinc-rich, epoxy or urethane primer containing a minimum of 77-percent zinc dust by weight, compatible with topcoats, and as instructed by topcoat manufacturer.

C. Shop Primers: Comply with Section 099600 "High-Performance Coatings."

2.6 FABRICATION

A. Shop fabricate and assemble AESS to the maximum extent possible. Locate field joints at concealed locations. Detail assemblies to minimize handling and to expedite erection.

B. Handling: The fabricator shall handle the steel with care to avoid marking or distorting the steel members:
   1. Slings shall be nylon-type or chains or wire rope with softeners.
   2. Care shall be taken to minimize damage to any shop paint or coating.
   3. When temporary braces or fixtures are required during fabrication or shipment, or to facilitate erection, care shall be taken to avoid blemishes or unsightly surfaces resulting from the use or removal of such temporary elements.
   4. Tack welds not incorporated into final welds shall be treated consistently with requirements for final welds.
   5. Backing and runoff tabs shall be removed and the welds ground smooth.
   6. Bolt heads in connections shall be on the same side, as specified, and consistent from one connection to another.

C. Fabrication Tolerances:
   1. Comply with ASTM A6/A6M and ASTM A500/A500M for permissible tolerances for member depth, width, out of square, and camber and sweep. The following exceptions apply:
      a. For Grade AESS 3, the matching of abutting cross sections shall be required.
b. For Grade AESS 3, the as-fabricated straightness tolerance shall be one-half of that specified in ASTM A6/A6M and ASTM A500/A500M.

2. The tolerance on overall profile dimensions of welded built-up members shall meet the requirements in AWS D1.1/D1.1M. For Grade AESS 3, the as-fabricated straightness tolerance for the member as a whole shall be one-half of that specified in AWS D1.1/D1.1M

3. For Grade AESS 3, copes, miters and cuts in surfaces exposed to view shall have a gap that is uniform within 1/8 in., if shown to be an open joint. If the joint is shown to be in contact, the contact shall be uniform within 1/16 in..

4. For Grade AESS 3, seams shall be oriented as directed by Architect.

D. Surface Condition: For Grade AESS 3, the surface condition of steel given in ASTM A6/A6M shall be acceptable.

E. Curved Members: Fabricate indicated members to curved shape by rolling to final shape in fabrication shop.

   1. Distortion of webs, stems, outstanding flanges, and legs of angles shall not be visible from a distance of 20 feet under any lighting conditions.
   2. Tolerances for walls of hollow steel sections after rolling shall be approximately 1/2 inch.
   3. The as-fabricated variation from the theoretical curvature shall be equal to or less than the standard camber and sweep tolerances permitted for straight members.

F. Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel members.

   1. Cut, drill, or punch holes perpendicular to steel surfaces. Do not thermally cut bolt holes or enlarge holes by burning.
   2. Baseplate Holes: Cut, drill, mechanically thermal cut, or punch holes perpendicular to steel surfaces.
   3. Weld threaded nuts to framing and other specialty items indicated to receive other work.

2.7 SHOP CONNECTIONS

A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.

   1. Joint Type: Slip critical.

B. Weld Connections: Comply with AWS D1.1/D1.1M and AWS D1.8/D1.8M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work, and comply with the following:

   1. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding specified tolerances.
   2. Use weld sizes, fabrication sequence, and equipment for AESS that limit distortions to allowable tolerances.
   3. Provide continuous, sealed welds at angle to gusset-plate connections and similar locations where AESS is exposed to weather.
   4. Provide continuous welds of uniform size and profile where AESS is welded.
   5. For Grade AESS 3, welds shall meet AWS D1.1/D1.1M requirements, except that weld spatter exposed to view, if any, shall be removed.
   6. For Grades AESS 3, welds shall be ground smooth/filled.
2.8 SHOP PRIMING

A. Shop prime steel surfaces except the following:
   1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.
   2. Surfaces to be field welded.
   3. Surfaces to be high-strength bolted with slip-critical connections.

B. Surface Preparation for Nongalvanized Steel: Clean surfaces to be painted with high-performance coatings. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:
   1. SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning."
   2. Prior to blast cleaning:
      a. Grease or oil, if any is present, shall be removed by solvent cleaning to meet the requirements of SSPC-SP 1.
      b. Weld spatter, slivers and similar surface discontinuities shall be removed.
      c. Sharp corners resulting from shearing, flame cutting or grinding shall be eased.

C. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 2.5 mils. Comply with requirements in SSPC-PA 1, "Shop, Field, and Maintenance Painting of Steel," for shop painting. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces. Do not apply primer to surfaces to be embedded in concrete or masonry.
   1. Shop prime uncoated steel with zinc-rich primer.
   2. Shop prime galvanized steel with shop primer for galvanized steel.
   3. Stripe paint corners, crevices, bolts, welds, and sharp edges.
   4. Apply two coats of shop paint to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish from first.

2.9 FINISHES, GENERAL

A. Finish metal fabrications after assembly.

B. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.

C. Finishing: For architecturally exposed steel items, apply high-performance coatings in accordance with Section 099600 "High-Performance Coatings."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify, with steel erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.
   1. Prepare a certified survey of bearing surfaces, anchor rods, bearing plates, and other embedments showing dimensions, locations, angles, and elevations.
B. Examine AESS for twists, kinks, warping, gouges, and other imperfections before erecting.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Provide temporary shores, guys, braces, and other supports during erection to keep AESS secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.

1. If possible, locate welded tabs for attaching temporary bracing and safety cabling where they will be concealed from view in the completed Work.

2. Do not remove temporary shoring supporting composite deck construction until cast-in-place concrete has attained its design compressive strength.

3.3 ERECTION

A. Plan and execute erection operations in such a manner that allows the architectural appearance of the structure to be maintained.

B. Set AESS accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.

1. Slings shall be nylon-type or chains or wire rope with softeners.

2. Care shall be taken to minimize damage to shop paint or coating.

3. When temporary braces or fixtures are required to facilitate erection, care shall be taken to avoid blemishes, holes or unsightly surfaces resulting from the use or removal of such temporary elements.

4. Tack welds not incorporated into final welds shall be ground smooth.

5. Backing and runoff tabs shall be removed and the welds ground smooth.

6. Bolt heads in connections shall be on the same side, as specified, and consistent from one connection to another.

C. Do not use thermal cutting during erection.

3.4 FIELD CONNECTIONS

A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.

1. Joint Type: Slip critical.

2. Orient bolt heads as indicated on Drawings.


3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to inspect AESS as specified in Section 051200 "Structural Steel Framing." The testing agency is not responsible for enforcing requirements relating to aesthetic effect.
B. Architect will observe AESS in place to determine acceptability relating to aesthetic effect.

3.6 REPAIRS AND PROTECTION

A. Remove welded tabs that were used for attaching temporary bracing and safety cabling and that are exposed to view in the completed Work. Grind steel smooth.

B. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces. Immediately before Date of Substantial Completion, clean, repair, and repaint scratches, gouges, and other such distortions caused by construction operations.
   1. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.

C. Touchup Priming and Painting: Cleaning, touchup priming, and touch-up painting are specified in Section 099600 "High-Performance Coatings."

END OF SECTION
SECTION 051250 - BUCKLING RESTRAINED BRACES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes:
   1. Furnishing buckling-restrained braces (BRB's).
   2. Engineering design of BRB's.
   3. Engineering design of BRB connection gussets.

B. Related Sections:
   1. Section 051200 – Structural Steel Framing for erection of BRB's and furnishing of connection hardware for BRB's, including loose plates and fasteners.

1.3 REFERENCES

A. Standards listed below apply where designation is cited in this Section. Where the applicable year of adoption or revision is not listed below, the latest edition applies.

B. ASTM: Standards of the American Society for Testing and Materials (ASTM) apply where designated in this Section. Use applicable year of adoption or revision as published in AISC 360-10.

C. American Institute of Steel Construction’s

D. American Welding Society’s

E. Research Council on Structural Connections’

F. SSPC: Latest edition of Society for Protective Coatings surface preparation and painting specifications apply where cited in this Section.
1.4 DEFINITIONS

A. Buckling-Restrained Brace (BRB): Specialty structural brace element consisting of an axial force resisting steel core encased by a system that prevents buckling of the steel core.

1. Tension and compression shall be resisted entirely by the steel core. The buckling restraining system shall prevent brace buckling and control plate buckling without restraining the steel core from longitudinal extension and shortening.

B. Design Axial Strength, $P_{yc}$: The tensile yield strength of the brace, as designated on the Drawings.

C. Core Area, $A_{sc}$: The Drawings designate a nominal core area to be used when the actual steel yield strength of the core plate is 40 ksi.

D. Stiffness Modification Factor, KF: The stiffness modification factor, as designated on the Drawings.

1.5 DESIGN AND PERFORMANCE REQUIREMENTS

A. Physical Requirements:

1. The area of the steel core, $A_{sc}$, shall be the nominal core area designated on the drawings.

2. The casing shall not exceed the maximum dimensions designated on the Drawings, without written approval of Owner’s Representative.

B. Performance Criteria:

1. Braces shall achieve the stiffness modification factor, KF, designated on sheet S5.30 of the Drawings, within the tolerance designated on the Drawings.

2. Braces shall provide for stable cyclic displacement (lengthening and shortening), corresponding to the acceptance criteria of ANSI/AISC 341, Section K3.

3. The axial brace strain, $2\varepsilon_{bm}$, shall be designated on sheet S5.30 of the Drawings.

C. Design Requirements For Contractor Substitution:

1. Buckling Restrained Braces and end connections are not a deferred approval item. The design requirements are noted in the DSA approved specifications and Drawings. If the Manufacturer chooses to propose substitutions that differs from that used as basis of design and approved by DSA, Manufacturer’s Engineer shall redesign the BRB’s and gusset plates shown on Drawings as required to accommodate connection configuration, subject to review and acceptance of both SEOR and DSA. Acceptance by DSA shall be via an addendum or CCD per DSA IR A-6. Review by SEOR is considered a request for a substitution. As such, SEOR to be compensated for such a review and revisions.

a. Manufacturer’s engineer shall design braces to achieve the performance criteria. Design shall be based on detailed examination and understanding of the results of qualifying cyclic tests and interpolation of results to project conditions.

b. Interpolation of test results for different member sizes shall be justified by rational analysis that demonstrates stress distributions and magnitudes of internal strains that are consistent with or less severe than the tested assemblies and that considers the adverse effects of larger material and variations in material properties. Consider the effect of imposed end rotations.
c. End connections: Manufacturer's Engineer shall design connections to develop the adjusted brace strength in compression, in accordance with provisions of AISC 341 and AISC 360.

1) Adjusted brace strength shall be taken as $1.1\omega\beta*46\cdot A_{sc}$, where $\omega\beta$ are determined at $2\sigma_{cm}$.
2) Bolts in oversize holes shall be designed not to slip prior to brace yield, using $1.1\cdot 46\cdot A_{sc}$ for determination of initial yield. Bolt slip capacity shall be computed using provisions of AISC 360 and a Class A faying surface.

D. Qualification Tests: The design of braces shall be based on results from qualifying cyclic tests in accordance with requirements of ANSI/AISC 341, Section K3.

1.6 SUBMITTALS


B. Certified Manufacturer’s Quality Assurance Plan: Conform to requirements of “Quality Assurance”.

C. Brace Design: Submit drawings and calculations signed by the Manufacturer’s Engineer. Submittal shall occur prior to securing a building permit from DSA. Brace design submittal shall show compliance with the requirements of Article 1.5. If Contractor proposes to deviate from DSA-approved document, Contractor to submit request for substitution via addendum or CCD.

1. Design drawings: Show size and configuration of steel core for full length of BRB. Indicate casing size and length. Provide details of welding.
2. Calculations: Include computations for core area, brace stiffness, casing size, and end connection. Include calculations for gusset plates, where revisions are necessary to accommodate actual end connections.

D. Certified Material Test Reports: Submit to Testing Laboratory for record purposes.

1. Steel.
2. Welding filler material.
3. Coupon tests for core plate steel.

E. Erection Drawings: Show location, size and end connection of BRB’s. Give complete information necessary for fabrication of elements of structural steel frame to receive braces and fabrication of connection plates. Show methods of assembly, including type and size of bolts, hole diameter, and preparation and finish of faying surfaces. Identify tolerances for fabrication and erection.

F. Testing and Inspection Reports: Submit Quality Assurance test and inspection reports to Testing Laboratory for record purposes prior to shipping of braces.

G. LEED Submittals. Submit for record purposes.

1. Recycled Content – Product Data for MR Credits 4.1 and 4.2: Indicate percentages by weight of postconsumer and pre-consumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.
2. Low-Emitting Materials – Product Data for EQ Credit 4.2: Provide manufacturers’ printed statement of VOC content, grams per liter, for primer paints.
1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: Shall have manufactured and successfully tested braces up to the maximum size and inelastic deformation designated on the Drawings.

B. Design Engineer Qualifications: Structural Engineer, registered in the State of California, that is knowledgeable with the results of cyclic testing of BRB's and experienced in the design of BRB’s based on engineering analysis.
   1. Engineer may be an employee of brace manufacturer.

C. Quality Assurance Plan: Manufacturer shall have a detailed quality assurance plan to evidence that the BRB’s being manufactured are of same quality as those tested.

D. Qualification Testing: Refer to Article 1.5 D, "Qualification Tests" for requirements.
   1. Extrapolation of qualification testing: All deviations from materials, details of fabrication, and quality assurance controls used for the fabrication of tested prototype braces shall be identified by manufacturer and reviewed by design engineer and acceptable to DSA to ensure that production braces meet or exceed the level of quality used in fabrication of prototype braces.

E. Coupon Testing:
   1. Randomly sample and tension test steel plate for brace core in accordance with ASTM E8, plate-type tests.
   2. Take samples from plates at point of brace manufacture.
      a. The axis of the test specimens shall be parallel to the axis of the brace core; no testing transverse to axis of brace core is required.
      b. The end of the test specimen shall be located 6 inches minimum from the end of plate.
      c. The centerline of the test specimen shall be located at the center of steel bars and not closer than 8 inches to a rolled edge of plate.
   3. Test a minimum of 3 specimens for each plate thickness, spaced sufficiently to be representative of the plate employed in the work.
      a. Where more than one heat is employed, test a minimum of 3 specimens from each heat of steel.
      b. Test 2 additional specimens whenever an individual test varies by more than 5 percent from the average of three specimen tests.
   4. Report initial yield, yield at 0.2 percent offset, tensile strength, and elongation for each specimen. Report average yield at 2 percent offset for each sample (of 3, or more, specimen tests).
   5. When the average lower yield strength for a sample falls outside of the specified tolerances designated on the Drawings, the steel shall be rejected for use on the project.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Basis of Design: The bolted lug-type end connection, as manufactured by CoreBrace serves as the basis of design for this project, including gusset plates shown on Drawings.
1. Substitution of other brace end connection types shall be acceptable for this project, subject to limitations specified herein. Brace manufacturer shall provide engineering design of gusset plates to accommodate end connection, subject to review and acceptance by Owner's Representative. Substitution of BRB is subject to DSA review and approval and shall be submitted as an addendum or CCD prepared and approved by the Architect or Record and Structural Engineer of Record. Substitution shall be at no additional cost to Owner, including required modifications to structural steel and re-design fees to Engineer of Record. Additional costs will include fees associated with the Architect, Structural Engineer and DSA-SS/CC.

B. The following manufacturer’s, which have successfully completed qualification testing of braces similar to those required for the project, will be considered acceptable manufacturers, subject to compliance with other requirements of the Contract Documents, including limitations on maximum brace dimensions.
   1. Nippon Steel Engineering USA, Inc.
      a. All bolted end connection shall be acceptable for this project.
      b. Pin end connection shall be acceptable for this project.
   2. CoreBrace™, West Jordan, UT.
      a. All bolted end connection shall be acceptable for this project.
      b. Bolted lug type end connections shall be acceptable for this project.

2.2 MATERIALS

A. Steel Plate for Core: ASTM A36, ASTM A572, Grade 42, or JIS G 3136, Grade SN400 B; except that tensile yield stress at 2 percent offset shall be as designated on the Drawings, as evidenced by coupon testing.

   1. Steel plates 2 inches (50 mm) and thicker shall be supplied with Charpy V-Notch testing in accordance with ASTM A6 Supplementary Requirement S5, or approved equal. The impact test shall meet a minimum average value of 20 ft-lbs absorbed energy at 70 degrees Fahrenheit when tested in accordance with ASTM A673, Frequency P.

B. Casing: ASTM A500, Grade B.

   1. For portions of casing that are exposed to view in completed construction, use only materials that are smooth and free of surface blemishes including pitting, scale, seam marks, roller marks, and rolled trade names. Remove such blemishes by grinding or by filling and grinding, prior to cleaning, treating, and applying surface finishes.

C. Welding Filler Material: Conform to requirements of AWS D1.8, Section 6.3; subject to meeting the CVN toughness and elongation of filler material used for fabrication of tested assemblies.

D. Debonding Agent: Manufacturer’s standard; demonstrated suitable to maintain separation of steel core and grout encasement when subjected to a minimum of 30 cycles of inelastic yielding at 2.0 percent strain; resistant to aging effects for a life cycle of 50 years.

E. Fill Material: Manufacturer’s standard cementitious grout; demonstrated suitable for function as a confining in-fill material by sub-assembly qualification testing.

   1. Grout shall have a minimum compressive strength of 3500 psi at 28 days (ASTM C109).
F. Shop Primer:
   1. Type A: Manufacturer’s standard zinc-rich rust preventative primer, free of lead and chromates.
   2. Type B: SSPC-Paint 20, Type II. Organic, zinc-rich primer; containing less than 0.002% lead. Acceptable Products: Series 90-97 Tneme-Zinc by Tnemec, Carbozinc 621 by Carboline, or approved equal.

2.3 FABRICATION

A. Fabricate steel in accordance with Division 05 Section, "Structural Steel Framing" for members that are part of the Seismic Load Resisting System.

B. Core Plates:
   1. Cut core plates to profile shown on manufacturer’s design drawings. Conform to tolerances of manufacturer’s Quality Assurance Manual, except tolerance on plate width shall not exceed plus or minus 0.2 inches (5 mm).
   2. Axis of core plates shall be parallel to rolling direction of steel plate.
   3. Splices in the steel core shall not be permitted.
   4. Roughness: After cutting, edges of core plates shall have surface finish better than Sample 3, AWS C4.1.
   5. Gouges and notches: Occasional gouges and notches less than 0.2 inches (5 mm) deep in edges of core plates may be repaired by grinding to a smooth transition. The length of transition shall be a minimum of 10 times the depth of gouge. The area shall be inspected by MT after grinding to ensure the entire depth of gouge has been removed. Deeper gouges shall be cause for rejection of piece.
   6. Welding: Continuously weld intersections of cruciform plates. The detailing and finishing of weld terminations shall meet or exceed quality of tested assembly.

C. Holes: Holes for bolted connections shall be drilled and burrs removed. Where designated on Drawings, oversize holes conforming to requirements of ANSI/AISC 360, will be permitted. Holes for pins shall be cut and finished in accordance with manufacturer’s approved procedures.

D. Assembly: Assemble components of the Buckling-Restrained Brace in a manner to ensure proper performance of the brace.
   1. Examine steel core areas for straightness prior to coating with debonding agent.
   2. Provide end-confining plates to ensure confinement of the fill material while allowing for non-restricting movement of the steel core.
      a. Where end confining plates are exposed to view in completed construction, grind flush with face of casing.
   3. For braces exposed-to-weather at building exterior, provide weatherproof gaskets at the ends of the casing that are not subject to deterioration due to sunlight exposure.

E. Finishes: Except as otherwise designated on Drawings, conform to the following finish and painting schedule, in accordance with requirements of Division 05 Section, Structural Steel:
   1. Interior, concealed by finishes or spray fireproofed: SSPC-2 surface preparation; no shop primer paint. At brace manufacturer’s option, concealed surfaces may be shop primed with manufacturer’s standard shop primer, except faying surfaces of bolted connections and surfaces to receive spray fireproofing.
2. Interior, exposed and finish painted: SSPC-6 surface preparation; Type A primer, except at faying surfaces of bolted connections.
3. Exterior, exposed and finish painted: SSPC-6 surface preparation; Type B primer. Faying surfaces of bolted connections shall be prime painted.

2.4 SOURCE QUALITY CONTROL

A. Inspection and testing will be performed in accordance with procedures and administrative requirements of Division 01 Section "Quality Requirements".

B. Testing Laboratory will:
   1. Review manufacturer's quality assurance plan, mill certificates and coupon test report.
   2. Review manufacturer's quality assurance test and inspection reports.

C. Contractor shall:
   1. Notify Owner's Representative no less than 30 days before the start of fabrication of the buckling-restrained braces, to allow Owner's Representative to observe fabrication and assembly process.
   2. Perform testing and inspection in accordance with approved quality assurance plan and requirements of contract documents.

PART 3 - EXECUTION

3.1 ERECTION

A. Braces are erected under Division 05 Section, "Structural Steel Framing".

B. Prior to erection, clean faying surfaces of brace to be in contact with bolted connections to remove temporary coatings applied for transport and surface contaminants.

C. Buckling-restrained braces shall not be field cut or altered. Alterations to structural steel components to receive Buckling-Restrained Braces shall be as permitted by Division 05 Section "Structural Steel Framing".

3.2 PROTECTION

A. Welded, bolted, screwed or shot-in attachments for nonstructural components, erection aids, or temporary construction shall not be placed within the protected zones of braces.
   1. The protected zone includes the steel core of the brace and elements that connect the core to beam and column framing.

B. Welded, bolted, screwed or shot-in attachments shall not be made to casing tube, except with approval of Owner's Representative and brace manufacturer.
3.3 WASTE MANAGEMENT (LEED MR Credit 2.1)

A. Separate steel waste and place in designated areas for recycling.

END OF SECTION
SECTION 053100 - STEEL DECKING

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes the following:
      1. Roof deck.
      2. Composite floor deck.
      3. Related accessories.
   B. Related Sections include the following:
      1. Section 031100 - Concrete Forming.
      2. Section 032000 - Concrete Reinforcing.
      3. Section 033000 - Cast-in-place Concrete.
      4. Section 051200 - Structural Steel Framing.
      5. Section 055000 - Metal Fabrications.

1.2 REFERENCES
   A. American Iron and Steel Institute (AISI) - North American Specification for the Design of Cold-Formed Steel Structural Members.
   D. Steel Deck Institute (SDI) – ANSI/SDI NC-2010, Standard for Non-Composite Steel Floor Deck.
   E. American Welding Society (AWS) D1.1 Structural Welding Code - Steel.
   F. American Welding Society (AWS) D1.3 Structural Welding Code - Sheet Steel.

1.3 SUBMITTALS
   A. Shop Drawings: Submit shop drawings in accordance with Section 01 33 00. Show layout and types of deck panels, anchorage details, attachment patterns, field welding requirements, side lap fastenings, reinforcing channels, pans, cut deck openings, special jointing, accessories, and attachments to other construction.
   B. Product Data: Submit manufacturer’s specifications/installation instructions for each type of deck, accessory, and product indicated.
      1. Include name of deck manufacturer, type, depth, uncoated steel thickness, and finish.
C. LEED Submittal:
   1. Product Data for Credit MR 4.1 and Credit MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. Product Data for Credit MR5.1 and Credit MR5.2: Product data for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material.
      a. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.

D. ICC-ES Evaluation Reports: Current evaluation reports by the ICC Evaluation Service indicating that the deck products provided are in compliance with the design requirements stated in the drawing and specification in accordance with the design code for the project.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Provide products from a manufacturer that is a member of the Steel Deck Institute.

B. Installer Qualifications: An experienced installer who has installed steel deck similar in material, design, and extent to that indicated for this Project with a record of successful in-service performance.


D. Fire-Test-Response Characteristics: Where indicated, provide steel deck units identical to those tested for fire resistance per ASTM E119 by a testing and inspecting agency acceptable to authorities having jurisdiction.
   1. Fire-Resistance Ratings: Units shall be rated and listed in Underwriters’ Laboratories “Fire Resistance Index”.
   2. Steel deck units shall be identified with appropriate markings of applicable testing and inspecting agency.

E. AISI Specifications: Comply with calculated structural characteristics of steel deck according to AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members."

F. SDI Publications: Fabricate panels to comply with the dimensional parameters and Standard Load Tables defined in SDI "Roof Deck Design Manual" and SDI "Floor Deck Design Manual", or as shown in the drawings.


H. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 50 percent.

I. Local Selection of Steel Products: Provide products for which the portion of material extracted, harvested, or recovered within 500 miles of the project site is not less than 50 percent.
1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect steel deck from corrosion, deformation, and other damage during delivery, storage, and handling.

B. Stack steel deck on platforms or pallets and slope to provide drainage. Protect with a waterproof covering and ventilate to avoid condensation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Steel Deck Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. ASC Profiles, Inc. per IAPMO UES ER 329 for floor deck and IAPMO UES ER 161 for roof deck.
   2. New Millennium Building Systems, per LLC ICC-ESR 3818.
   3. Verco Manufacturing Co. per IAPMO UES ER 217.

2.2 ROOF DECK

A. Steel Roof Deck: Fabricate panels, without top-flange stiffening grooves, to comply with ANSI/SDI RD-2010, “Standard for Steel Roof Deck,” and with the following:
   1. Galvanized Steel Sheet: ASTM A653, Structural Steel (SS), Grade 33, G60 zinc coating.
   2. Deck Profile: As indicated on drawings.
   3. Profile Depth: As indicated on drawings.
   4. Design Uncoated-Steel Thickness: As indicated on drawings.
   5. Span Condition: Minimum double span condition unless noted otherwise on drawings.

2.3 COMPOSITE FLOOR DECK

A. Composite Steel Floor Deck: Fabricate panels, with integrally embossed or raised pattern ribs and interlocking side laps, to comply with ANSI/SDI C-2011, “Standard for Composite Steel Floor Deck – Slabs,” with the minimum section properties indicated, and with the following:
   1. Profile Depth: As indicated on drawings.
   2. Design Uncoated-Steel Thickness: As indicated on drawings.
   3. Span Condition: Minimum double span condition unless noted otherwise on drawings.
   4. Side Laps: As indicated on drawings.

2.4 DECKING TO RECEIVE SFRM

A. Provide decking to receive spray-applied fire resistive materials free of amounts of lubricants, oils, or other contaminants which would impair the adhesion of spray-applied materials.
2.5 ACCESSORIES

A. General: Provide manufacturer's standard accessory materials for deck that comply with requirements indicated.

B. Welding Electrodes: Comply with AWS requirements.

C. Mechanical Fasteners: Corrosion-resistant, low-velocity, power-actuated or pneumatically driven carbon-steel fasteners; or self-drilling, self-threading screws.

D. Side-Lap Screw Fasteners: Corrosion-resistant, hexagonal washer head; self-drilling, carbon-steel screws, No. 12 minimum diameter unless indicated otherwise on drawings.

E. Provide approved manufacturer's standard side-lap connectors, as evidenced by an active evaluation report, where designated on drawings.

F. Miscellaneous Sheet Metal Deck Accessories: Steel sheet, minimum yield strength of 33,000 psi, of same thickness, material and finish as deck; of profile indicated or required for application.

G. Pour Stops and Girder Fillers: Steel sheet, minimum yield strength of 33,000 psi, of same material and finish as deck, and of thickness and profile recommended by SDI for overhang and slab depth.

H. Column Closures, End Closures, Z-Closures, and Cover Plates: Steel sheet, of same material, finish, and thickness as deck, unless otherwise indicated.

I. Flat Sump Plate: Single-piece steel sheet, 14 ga (0.0747 inch) thick, of same material and finish as deck. For drains, cut holes in the field.

J. Galvanizing Repair Paint: SSPC-Paint 20 or DOD-P-21035, with dry film containing a minimum of 94 percent zinc dust by weight. Comply with requirements of ASTM A780.

K. Repair Paint: Manufacturer's standard rust-inhibitive primer of same color as primer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine supporting frame and field conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

3.2 INSTALLATION, GENERAL

A. Install deck panels and accessories according to applicable SDI specifications, manufacturer's written instructions, and requirements in this Section.

B. Install temporary shoring before placing deck panels, if required by SDI specifications to meet deflection limitations and prevent overloading due to construction loads.

C. Locate deck bundles to prevent overloading of supporting members.
D. Place deck panels on supporting frame and adjust to final position with ends accurately aligned and bearing on supporting frame before being permanently fastened. Do not stretch or contract side-lap interlocks.

E. Place deck panels flat and square and fasten to supporting frame without warp or deflection.

F. Cut and neatly fit deck panels and accessories around openings and other work projecting through or adjacent to deck.

G. Provide additional reinforcement and closure pieces at openings as required for strength, continuity of deck, and support of other work.

H. Comply with AWS requirements and procedures for manual shielded metal arc welding, appearance and quality of welds, and methods used for correcting welding work.

3.3 ROOF-DECK INSTALLATION

A. Install roof deck as specified below unless noted otherwise on drawings.

B. Fasten roof-deck panels to steel supporting members by arc spot (puddle) welds of the surface diameter indicated or arc seam welds with an equal perimeter that is not less than 1½ inches, and as follows:
   1. Weld Diameter: As indicated on drawings.
   2. Weld Spacing: Weld edge and interior ribs of deck units with a minimum of two welds per deck unit at each support. Space welds as indicated on drawings.
   3. Weld Spacing in Corner Zones: Space welds 6 inches apart in the roof corners and perimeter zones. Roof corner dimension to be 8'-6” square, and perimeter zone to 8'-6” wide.

C. End Bearing: Install deck ends over supporting frame with a minimum end bearing of 1-1/2 inches, with end joints as follows:
   1. End Joints: Lapped 2 inches minimum.

D. Roof Sump Pans and Sump Plates: Install over openings provided in roof deck and weld flanges to top of deck. Space welds not more than 8 inches apart with at least one weld at each corner.
   1. Install reinforcing channels or zees in ribs to span between supports and weld.

E. Miscellaneous Roof-Deck Accessories: Install ridge and valley plates, finish strips, end closures, and reinforcing channels according to deck manufacturer’s written instructions. Weld to substrate to provide a complete deck installation.
   1. Weld cover plates at changes in direction of roof-deck panels, unless otherwise indicated.

F. Hanger attachments to roof deck shall be permitted only for support of suspended ceilings. Support of light fixtures, ducts, pipes or other utilities from roof deck is not permitted.

3.4 FLOOR-DECK INSTALLATION

A. Install floor deck as specified below unless noted otherwise on drawings.
B. Fasten floor-deck panels to steel supporting members by arc spot (puddle) welds of the surface diameter indicated and as follows:
   1. Weld Diameter: As indicated on drawings, nominal.
   2. Welded shear connector may replace deck welds.
   3. Weld Spacing: Space and locate welds as indicated on drawings.

C. Side-Lap and Perimeter Edge Fastening: Fasten side laps and perimeter edges of panels between supports, at intervals indicated on drawings.

D. End Bearing: Install deck ends over supporting frame with a minimum end bearing of 2 1/2 inches, with end joints as follows:
   1. End Joints: Butted.

E. Pour Stops and Girder Fillers: Weld steel sheet pour stops and girder fillers to supporting structure according to SDI recommendations, unless otherwise indicated.

F. Floor Deck Closures: Weld steel sheet column closures, cell closures, and Z-closures to deck, according to SDI recommendations, to provide tight-fitting closures at open ends of ribs and sides of decking. Weld cover plates at changes in direction of floor deck panels, unless otherwise indicated. Cell closures should not run continuous across low deck flutes where interfering with shear connector stud installation in accordance with AWS.

G. Accessories: Cut and fit decking units and accessories around other work projecting through or adjacent to decking according to deck manufacturer’s written instructions. Provide neat, square and trim cuts. Weld to substrate to provide a complete deck installation.

H. Sump Pan and Sump Plates: Place drain sump pans over openings in decking and weld to top of decking. Space welds not more than 8 inches on-center with at least one weld at each corner.

I. Floor openings shown on the structural drawings shall be cut by deck installer and, unless specifically noted otherwise, other openings shall be field cut by trade involved. Holes or openings in deck not shown on drawings shall be approved by Architect/Engineer prior to cutting.

3.5 FIELD QUALITY CONTROL

A. Deck Welds: On a periodic basis, visually inspect size, location, length and burn-through for 100% of puddle welds on metal deck per AWS D1.3, Section 6.

B. Mechanical Fasteners: On a periodic basis, visually inspect specified size, spacing, embedment and location.

C. Remove and replace work that does not comply with specified requirements.

D. Additional inspecting, at Contractor’s expense, will be performed to determine compliance of corrected work with specified requirements.
3.6 REPAIRS AND PROTECTION

A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on both surfaces of deck with galvanized repair paint according to ASTM A780 and manufacturer’s written instructions.

B. Provide final protection and maintain conditions to ensure that steel deck is without damage or deterioration at time of Substantial Completion.

END OF SECTION
SECTION 054000 - COLD-FORMED METAL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Load-bearing wall framing.
   2. Exterior non-load-bearing wall framing.

B. Related Requirements:
   1. Section 092216 "Non-Structural Metal Framing" for interior non-load-bearing, metal-stud framing and ceiling-suspension assemblies.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of cold-formed steel framing product and accessory.

B. Shop Drawings:
   1. Include layout, spacings, sizes, thicknesses, and types of cold-formed steel framing; fabrication; and fastening and anchorage details, including mechanical fasteners.
   2. Indicate reinforcing channels, opening framing, supplemental framing, strapping, bracing, bridging, splices, accessories, connection details, and attachment to adjoining work.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Welding certificates.

C. Product Test Reports: For each listed product, for tests performed by manufacturer and witnessed by a qualified testing agency or by a qualified testing agency.
   1. Steel sheet.
   2. Expansion anchors.
   4. Mechanical fasteners.
   5. Vertical deflection clips.
   6. Horizontal drift deflection clips
   7. Miscellaneous structural clips and accessories.

D. Research Reports:
1. For non-standard cold-formed steel framing, from ICC-ES, or equivalent.
2. For anchors, from ICC-ES, or equivalent.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Member in good standing of the Steel Framing Industry Association (SFIA) or member of a similar organization that provides verifiable code compliance program or shall have a current third-party evaluation report.
   1. Products shall be certified under an independent third party inspection program administered by an agency accredited by IAS to ICC-ES AC98 IAS Accreditation Criteria for Inspection Agencies.

B. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated.

C. Product Tests: Mill certificates or data from a qualified independent testing agency, or in-house testing with calibrated test equipment indicating steel sheet complies with requirements, including base-metal thickness, yield strength, tensile strength, total elongation, chemical requirements, and metallic-coating thickness.

D. Code-Compliance Certification of Studs and Tracks: Provide documentation that framing members are certified according to the product-certification program of the Steel Framing Industry Association (SFIA) or by a similar organization that provides verifiable code compliance program or shall have a current third-party evaluation report.

E. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

F. AISI Specifications and Standards: Comply with AISI S100 "North American Specification for the Design of Cold-Formed Steel Structural Members" and AISI S200 "Standard for Cold-Formed Steel Framing - General Provisions."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect cold-formed steel framing from corrosion, moisture staining, deformation, and other damage during delivery, storage, and handling.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. CEMCO: California Expanded Metal Products Company.
   2. ClarkDietrich Building Systems, Inc.
   3. MarinoWARE.
   4. SCAFCO Corporation
   5. Steel Network, Inc. (The).
2.2 PERFORMANCE REQUIREMENTS

A. Cold-Formed Steel Framing Design Standards:
   1. Wall Studs: AISI S211.

B. AISI Specifications and Standards:  Unless more stringent requirements are indicated, comply with AISI S100 and AISI S200.

C. Fire-Resistance Ratings:  Comply with ASTM E 119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Indicate design designations from UL’s "Fire Resistance Directory" or from the listings of another qualified testing agency.

2.3 COLD-FORMED STEEL FRAMING, GENERAL

A. Recycled Content of Steel Products:  Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Steel Sheet:  ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated, of grade and coating weight as follows:
   1. Grade:  Refer to Drawings.
   2. Coating:  G90 or equivalent.

C. Steel Sheet for Vertical Deflection and/or Drift Clips:  ASTM A 653/A 653M, structural steel, zinc coated, of grade and coating as follows:
   1. Grade:  Refer to Drawings.
   2. Coating:  G90.

2.4 LOAD-BEARING WALL FRAMING

A. Steel Studs:  Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges, and as follows:
   1. Minimum Base-Metal Thickness: Refer to Drawings.
   2. Flange Width: Refer to Drawings.

B. Steel Track:  Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with straight flanges, and as follows:
   1. Minimum Base-Metal Thickness: Refer to Drawings.
   2. Flange Width: Refer to Drawings.

C. Steel Box or Back-to-Back Headers:  Manufacturer's standard C-shapes used to form header beams, of web depths indicated, unpunched, with stiffened flanges, and as follows:
   1. Minimum Base-Metal Thickness: Refer to Drawings.
   2. Flange Width: Refer to Drawings.

D. Steel Single- or Double-L Headers:  Manufacturer's standard L-shapes used to form header beams, of web depths indicated, and as follows:
1. Minimum Base-Metal Thickness: Refer to Drawings.
2. Flange Width: Refer to Drawings.

2.5 EXTERIOR NON-LOAD-BEARING WALL FRAMING

A. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges, and as follows:
   1. Minimum Base-Metal Thickness: Refer to Drawings
   2. Flange Width: Refer to Drawings

B. Steel Track: Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with unstiffened flanges, and as follows:
   1. Minimum Base-Metal Thickness: Refer to Drawings.
   2. Flange Width: Refer to Drawings.

C. Vertical Deflection Clips: Manufacturer's standard bypass or head clips, capable of accommodating upward and downward vertical displacement of primary structure through positive mechanical attachment to stud web.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. ClarkDietrich Building Systems, Inc.
      b. MarinoWARE.
      c. SCAFCO Corporation.
      d. Steel Network, Inc. (The).

D. Single Deflection Track: Manufacturer's single, deep-leg, U-shaped steel track; unpunched, with unstiffened flanges, of web depth to contain studs while allowing free vertical movement, with flanges designed to support horizontal loads and transfer them to the primary structure, and as follows:
   1. Minimum Base-Metal Thickness: Refer to Drawings.
   2. Flange Width: Refer to Drawings.

E. Double Deflection Tracks: Manufacturer's double, deep-leg, U-shaped steel tracks, consisting of nested inner and outer tracks; unpunched, with unstiffened flanges.
   1. Outer Track: Of web depth to allow free vertical movement of inner track, with flanges designed to support horizontal loads and transfer them to the primary structure, and as follows:
      a. Minimum Base-Metal Thickness: Refer to Drawings.
      b. Flange Width: Refer to Drawings.
   2. Inner Track: Of web depth indicated, and as follows:
      a. Minimum Base-Metal Thickness: Refer to Drawings
      b. Flange Width: Refer to Drawings.

F. Drift Clips: Manufacturer's standard bypass or head clips, capable of isolating wall stud from upward and downward vertical displacement and lateral drift of primary structure through positive mechanical attachment to stud web and structure.
2.6 SOFFIT FRAMING

A. Exterior Soffit Frame: Manufacturer's standard C-shaped steel sections, of web depths indicated, with stiffened flanges, and as follows:
   1. Minimum Base-Metal Thickness: Refer to Drawings.
   2. Flange Width: Refer to Drawings.

2.7 FRAMING ACCESSORIES

A. Fabricate steel-framing accessories from steel sheet, ASTM A 1003/A 1003M, Structural Grade, Type H, metallic coated, of same grade and coating weight used for framing members.

B. Provide accessories of manufacturer's standard thickness and configuration, unless otherwise indicated, as follows:
   1. Supplementary framing.
   2. Bracing, bridging, and solid blocking.
   3. Web stiffeners.
   4. Anchor clips.
   5. End clips.
   6. Foundation clips.
   7. Gusset plates.

2.8 ANCHORS, CLIPS, AND FASTENERS

A. Steel Shapes and Clips: ASTM A 36/A 36M, zinc coated by hot-dip process according to ASTM A 123/A 123M.

B. Anchor Bolts: ASTM F 1554, Grade 36, threaded carbon-steel hex-headed bolts or headless bolts, with encased end threaded of dimensions indicated, and with carbon-steel nuts; and flat, hardened-steel washers; zinc coated by hot-dip process according to ASTM A 153/A 153M, Class C.
   1. Product: See Drawings.

C. Expansion Anchors: Fabricated from corrosion-resistant materials, with allowable load or strength design capacities calculated according to ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing per ASTM E 488 conducted by a qualified testing agency.
   1. Product: See Drawings.

D. Power-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with allowable load capacities calculated according to ICC-ES AC70, greater than or equal to the design load, as determined by testing per ASTM E 1190 conducted by a qualified testing agency.
   1. Product: See Drawings.

E. Mechanical Fasteners: ASTM C 1513, corrosion-resistant-coated, self-drilling, self-tapping, steel drill screws.
1. Head Type: Low-profile head beneath sheathing, manufacturer’s standard elsewhere.

F. Welding Electrodes: Comply with AWS standards.

2.9 MISCELLANEOUS MATERIALS

A. Galvanizing Repair Paint: SSPC-Paint 20 or MIL-P-21035B.

B. Nonmetallic, Nonshrink Grout: Premixed, nonmetallic, noncorrosive, nonstaining grout containing selected silica sands, portland cement, shrinkage-compensating agents, and plasticizing and water-reducing agents, complying with ASTM C 1107/C 1107M, with fluid consistency and 30-minute working time.

C. Shims: Load bearing, high-density multimonomer plastic, and nonleaching; or of cold-formed steel of same grade and coating as framing members supported by shims.

2.10 FABRICATION

A. Fabricate cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened, according to referenced AISI’s specifications and standards, manufacturer’s written instructions, and requirements in this Section.

1. Fabricate framing assemblies using jigs or templates.
2. Cut framing members by sawing or shearing; do not torch cut.
3. Fasten cold-formed steel framing members by welding. Wire tying of framing members is not permitted.
   a. Comply with AWS D1.3/D1.3M requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
   b. Locate mechanical fasteners and install according to Shop Drawings, with screw penetrating joined members by no fewer than three exposed screw threads.
4. Fasten other materials to cold-formed steel framing by welding, bolting, pneumatic pin fastening, or screw fastening, according to Shop Drawings.

B. Reinforce, stiffen, and brace framing assemblies to withstand handling, delivery, and erection stresses. Lift fabricated assemblies to prevent damage or permanent distortion.

C. Fabrication Tolerances: Fabricate assemblies level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet and as follows:

1. Spacing: Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.
2. Squareness: Fabricate each cold-formed steel framing assembly to a maximum out-of-square tolerance of 1/8 inch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine supporting substrates and abutting structural framing for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Install load bearing shims or grout between the underside of load-bearing wall bottom track and the top of foundation wall or slab at locations with a gap larger than 1/4 inch to ensure a uniform bearing surface on supporting concrete or masonry construction.

3.3 INSTALLATION, GENERAL

A. Cold-formed steel framing may be shop or field fabricated for installation, or it may be field assembled.

B. Install cold-formed steel framing according to AISI S200 and to manufacturer's written instructions unless more stringent requirements are indicated.

C. Install shop- or field-fabricated, cold-formed framing and securely anchor to supporting structure.
   1. Screw, bolt, or weld wall panels at horizontal and vertical junctures to produce flush, even, true-to-line joints with maximum variation in plane and true position between fabricated panels not exceeding 1/16 inch.

D. Install cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened.
   1. Cut framing members by sawing or shearing; do not torch cut.
   2. Fasten cold-formed steel framing members by welding, screw fastening, clinch fastening, or riveting. Wire tying of framing members is not permitted.
      a. Comply with AWS D1.3/D1.3M requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
      b. Locate mechanical fasteners and install according to Shop Drawings, and complying with requirements for spacing, edge distances, and screw penetration.

E. Install framing members in one-piece lengths unless splice connections are indicated for track or tension members.

F. Install temporary bracing and supports to secure framing and support loads comparable in intensity to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.

G. Do not bridge building expansion joints with cold-formed steel framing. Independently frame both sides of joints.

H. Install insulation, specified in Section 072100 "Thermal Insulation," in built-up exterior framing members, such as headers, sills, boxed joists, and multiple studs at openings, that are inaccessible on completion of framing work.

I. Attach exterior sheathing to exterior framing members in accordance with Section 061600 "Sheathing." Confirm gauge of framing with item to be supported according to deflection criteria indicated.
J. Apply continuous air-barrier and rigid insulation, where shown, to sheathing in accordance with Division 07.

K. Fasten hole reinforcing plate over web penetrations that exceed size of manufacturer's approved or standard punched openings.

L. Erection Tolerances: Install cold-formed steel framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet and as follows:
   1. Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.

3.4 LOAD-BEARING WALL INSTALLATION

A. Install continuous top and bottom tracks sized to match studs. Align tracks accurately and securely anchor at corners and ends, and at spacings as follows:
   1. Anchor Spacing: Refer to Drawings.

B. Squarely seat studs against top and bottom tracks with gap not exceeding of 1/8 inch between the end of wall framing member and the web of track. Fasten both flanges of studs to top and bottom tracks. Space studs as follows:
   1. Stud Spacing: Refer to Drawings.

C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar configurations.

D. Align studs vertically where floor framing interrupts wall-framing continuity. Where studs cannot be aligned, continuously reinforce track to transfer loads.

E. Anchor studs abutting structural columns or walls, including masonry walls, to supporting structure as indicated.

F. Install headers over wall openings wider than stud spacing. Locate headers above openings as indicated. Fabricate headers of compound shapes indicated or required to transfer load to supporting studs, complete with clip-angle connectors, web stiffeners, or gusset plates.
   1. Frame wall openings with not less than a double stud at each jamb of frame. Fasten jamb members together to uniformly distribute loads.
   2. Install runner tracks and jack studs above and below wall openings. Anchor tracks to jamb studs with clip angles or by welding, and space jack studs same as full-height wall studs.

G. Install supplementary framing, blocking, and bracing in stud framing indicated to support fixtures, equipment, services, casework, heavy trim, furnishings, and similar work requiring attachment to framing.
   1. If type of supplementary support is not indicated, comply with stud manufacturer's written recommendations and industry standards in each case, considering weight or load resulting from item supported.

H. Install horizontal bridging in stud system, spaced vertically as indicated on Drawings. Fasten at each stud intersection.
I. Install miscellaneous framing and connections, including supplementary framing, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.

3.5 EXTERIOR NON-LOAD-BEARING WALL INSTALLATION

A. Install continuous tracks sized to match studs. Align tracks accurately and securely anchor to supporting structure as indicated.

B. Fasten both flanges of studs to top and bottom track unless otherwise indicated. Space studs as follows:
   1. Stud Spacing: Refer to Drawings.

C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar requirements.

D. Isolate non-load-bearing steel framing from building structure to prevent transfer of vertical loads while providing lateral support.
   1. Install single deep-leg deflection tracks and anchor to building structure.
   2. Install double deep-leg deflection tracks and anchor outer track to building structure.
   3. Connect vertical deflection clips to bypassing and infill studs and anchor to building structure.
   4. Connect drift clips to cold-formed metal framing and anchor to building structure.

E. Install horizontal bridging in wall studs, spaced vertically in rows but not more than 48 inches apart. Fasten at each stud intersection.
   1. Top Bridging for Single Deflection Track: Install row of horizontal bridging within 18 inches of single deflection track according to one of the methods below. Install a combination of bridging and stud or stud-track solid blocking of width and thickness matching studs, secured to stud webs or flanges.
   2. Bridging: One of the following:
      a. Cold-rolled steel channel, welded or mechanically fastened to webs of punched studs.
      b. Combination of flat, taut, steel sheet straps of width and thickness indicated and stud-track solid blocking of width and thickness to match studs. Fasten flat straps to stud flanges and secure solid blocking to stud webs or flanges.
      c. Proprietary bridging bars installed according to manufacturer’s written instructions.

F. Install miscellaneous framing and connections, including stud kickers, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.

3.6 CEILING/SOFFIT JOIST INSTALLATION

A. Install perimeter joist track sized to match joists. Align and securely anchor or fasten track to supporting structure at corners and ends.

B. Install joists bearing on supporting frame, level, straight, and plumb; adjust to final position, brace, and reinforce. Fasten joists to both flanges of joist track.
   1. Install joists over supporting frame with a minimum end bearing of 1-1/2 inches.
2. Reinforce ends and bearing points of joists with web stiffeners, end clips, joist hangers, steel clip angles, or steel-stud sections as indicated on Shop Drawings.

C. Space joists not more than 2 inches from abutting walls, and as follows:
   1. Joist Spacing: Refer to Drawings.

D. Frame openings with built-up joist headers consisting of joist and joist track, or another combination of connected joists if indicated.

E. Install joist reinforcement at interior supports with single, short length of joist section located directly over interior support, with lapped joists of equal length to joist reinforcement, or as indicated on Shop Drawings.

F. Install bridging at intervals indicated on Drawings. Fasten bridging at each joist intersection according to one of the following:
   1. Bridging: Joist-track solid blocking of width and thickness indicated, secured to joist webs, or
   2. Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and joist-track solid blocking of width and thickness indicated. Fasten flat straps to bottom flange of joists and secure solid blocking to joist webs.
   3. Bridging: Manufacturer’s proprietary installation method.

G. Secure joists to load-bearing interior walls to prevent lateral movement of bottom flange.

H. Install miscellaneous joist framing and connections, including web stiffeners, closure pieces, clip angles, continuous angles, hold-down angles, anchors, and fasteners, to provide a complete and stable joist-framing assembly.

3.7 FIELD QUALITY CONTROL

A. Testing: District will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Field and shop welds will be subject to testing and inspecting.

C. Testing agency will report test results promptly and in writing to Contractor and Architect.

D. Remove and replace work where test results indicate that it does not comply with specified requirements.

E. Additional testing and inspecting, at Contractor’s expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.8 REPAIRS AND PROTECTION

A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed steel framing with galvanized repair paint according to ASTM A 780 and manufacturer’s written instructions.

B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that cold-formed steel framing is without damage or deterioration at time of Substantial Completion.
SECTION 055000 - METAL FABRICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Steel framing and supports for countertops.
   2. Steel tube reinforcement for low partitions.
   3. Steel framing and supports for mechanical and electrical equipment.
   4. Steel framing and supports for applications where framing and supports are not specified in other Sections.
   5. Elevator machine beams, hoist beams, and divider beams.
   6. Steel shapes for supporting elevator door sills.
   7. Shelf angles.
   8. Metal ladders.
   10. Miscellaneous steel trim.
   11. Metal bollards.
   13. Loose bearing and leveling plates for applications where they are not specified in other Sections.

B. Products furnished, but not installed, under this Section include the following:
   1. Loose steel lintels.
   2. Anchor bolts, steel pipe sleeves, slotted-channel inserts, and wedge-type inserts indicated to be cast into concrete or built into unit masonry.

C. Related Requirements:
   1. Section 033000 "Cast-in-Place Concrete" for installing anchor bolts, steel pipe sleeves, slotted-channel inserts, wedge-type inserts, and other items cast into concrete.
   2. Section 051200 "Structural Steel Framing."

1.3 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers’ written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of metal fabrications that are anchored to or that receive other work. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.
1.4 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Nonslip aggregates and nonslip-aggregate surface finishes.
   2. Metal nosings and treads.
   3. Paint products.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Show fabrication and installation details for metal fabrications.
   1. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items.

D. Samples for Verification: For each type and finish of extruded nosing.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
   2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
   3. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

C. Provide the following upon request:
   1. Qualification Data: For professional engineer.
   2. Mill Certificates: Signed by stainless-steel manufacturers, certifying that products furnished comply with requirements.
   3. Welding certificates.
   4. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.
   5. Research/Evaluation Reports: For post-installed anchors, from ICC-ES.

1.6 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 METALS

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.
B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

C. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

D. Stainless-Steel Sheet, Strip, and Plate: ASTM A 240/A 240M or ASTM A 666, Type 316.

E. Stainless-Steel Bars and Shapes: ASTM A 276, Type 316.

F. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from plate complying with ASTM A 36/A 36M or ASTM A 283/A 283M, Grade C or D.

G. Steel Tubing: ASTM A 500/A 500M, cold-formed steel tubing, Grade B, unless otherwise indicated.

H. Steel Pipe: ASTM A 53/A 53M, Standard Weight (Schedule 40), unless otherwise indicated.

I. Slotted Channel Framing: Cold-formed metal box channels (struts) complying with MFMA-4.
   2. Material: Galvanized steel, ASTM A 653/A 653M, commercial steel, Type B, with G90 coating; 0.108-inch nominal thickness.

J. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.


N. Aluminum Castings: ASTM B 26/B 26M, Alloy 443.0-F.

2.2 FASTENERS

A. General: Unless otherwise indicated, provide Type 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633 or ASTM F 1941, Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.
   1. Provide stainless-steel fasteners for fastening aluminum.
   2. Provide stainless-steel fasteners for fastening stainless steel.

B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A; with hex nuts, ASTM A 563; and, where indicated, flat washers. Unless otherwise indicated in Drawings, use as specified herein.

C. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 325, Type 3; with hex nuts, ASTM A 563, Grade C; and, where indicated, flat washers. Use where indicated in Drawings.

D. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, ASTM F 593; with hex nuts, ASTM F 594; and, where indicated, flat washers; Alloy [Group 1] [Group 2].

E. Anchor Bolts: ASTM F 1554, Grade 36, of dimensions indicated; with nuts, ASTM A 563; and, where indicated, flat washers.
1. Hot-dip galvanize or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.

F. Eyebolts: ASTM A 489.

G. Machine Screws: ASME B18.6.3.


I. Wood Screws: Flat head, ASME B18.6.1.


L. Anchors, General: Anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488/E 488M, conducted by a qualified independent testing agency.
   1. Product: Refer to Drawings.

M. Cast-in-Place Anchors in Concrete: Either threaded type or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A 47/A 47M malleable iron or ASTM A 27/A 27M cast steel. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F 2329.
   1. Product: Refer to Drawings.

N. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors.
   1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941, Class Fe/Zn 5, unless otherwise indicated.
      a. Product: Refer to Drawings.
      a. Product: Refer to Drawings.

O. Slotted-Channel Inserts: Cold-formed, hot-dip galvanized-steel box channels (struts) complying with MFMA-4, 1-5/8 by 7/8 inches by length indicated with anchor straps or studs not less than 3 inches long at not more than 8 inches o.c. Provide with temporary filler and tee-head bolts, complete with washers and nuts, all zinc-plated to comply with ASTM B 633, Class Fe/Zn 5, as needed for fastening to inserts.

2.3 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with, approved by, and listed with MPI and compatible with topcoat.
   1. Comply with MPI #79.
   2. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
C. Epoxy Zinc-Rich Primer: Complying with, approved by, and listed with MPI and compatible with topcoat.
   1. Comply with MPI #20.

D. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish paint systems indicated.

E. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

F. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187/D 1187M.

G. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.

H. Concrete: Comply with requirements in Section 033000 "Cast-in-Place Concrete" for normal-weight, air-entrained, concrete with a minimum 28-day compressive strength of 3000 psi.

2.4 FABRICATION, GENERAL

A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

D. Form exposed work with accurate angles and surfaces and straight edges.

E. Weld corners and seams continuously to comply with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.

G. Fabricate seams and other connections that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
I. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

1. Where units are indicated to be cast into concrete or built into masonry, equip with integrally welded steel strap anchors, 1/8 by 1-1/2 inches, with a minimum 6-inch embedment and 2-inch hook, not less than 8 inches from ends and corners of units and 24 inches o.c., unless otherwise indicated.

2.5 MISCELLANEOUS FRAMING AND SUPPORTS

A. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.

B. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.

C. Galvanize exterior miscellaneous framing and supports. Prime and paint exposed galvanized steel in accordance with Section 099113 "Exterior Painting."

D. Prime and paint interior miscellaneous framing and supports in accordance with Section 099123 "Interior Painting."

2.6 SHELF ANGLES

A. Fabricate shelf angles from steel angles of sizes indicated and for attachment to concrete framing. Provide horizontally slotted holes to receive 3/4-inch bolts, spaced not more than 6 inches from ends and 24 inches o.c., unless otherwise indicated.

1. Provide mitered and welded units at corners.
2. Provide open joints in shelf angles at expansion and control joints. Make open joint approximately 2 inches larger than expansion or control joint.

B. For cavity walls, provide vertical channel brackets to support angles from backup masonry and concrete.

C. Galvanize shelf angles located in exterior walls.

D. Furnish wedge-type concrete inserts, complete with fasteners, to attach shelf angles to cast-in-place concrete.

2.7 METAL LADDERS

A. General:

2. For elevator pit ladders, comply with ASME A17.1/CSA B44.

B. Steel Ladders:

1. Space siderails as indicated, but not less than 16 inches apart.
2. Siderails: Continuous, steel flat bars as indicated, with eased edges.
3. Rungs: Steel bars as indicated.
4. Fit rungs in centerline of siderails; plug-weld and grind smooth on outer rail faces.
5. Provide nonslip surfaces on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung filled with aluminum-oxide grout.

6. Support each ladder at top and bottom and not more than 60 inches o.c. with welded or bolted steel brackets.

7. Galvanize ladders, including brackets.

C. For ladders accessed from exterior grade, provide minimum 72-inch-high, hinged security door with padlock hasp at foot of ladder to prevent unauthorized ladder use.

2.8 ELEVATOR PIT SUMP COVERS

A. Fabricate from welded or pressure-locked steel bar grating Limit openings in gratings to no more than 3/4 inch in least dimension.

B. Provide steel angle supports as indicated.

2.9 MISCELLANEOUS STEEL TRIM

A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.

B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.

1. Provide with integrally welded steel strap anchors for embedding in concrete or masonry construction.

C. Galvanize exterior miscellaneous steel trim and finish as directed by Architect.

D. Prime and paint interior miscellaneous steel trim in accordance with Section 099123 "Interior Painting."

2.10 METAL BOLLARDS

A. Fabricate metal bollards from Schedule 40 steel pipe.

1. Cap bollards with 1/4-inch-thick steel plate.
2. Where bollards are indicated to receive controls for door operators, provide cutouts for controls and holes for wire.
3. Where bollards are indicated to receive light fixtures, provide cutouts for fixtures and holes for wire.

B. Fabricate sleeves for bollard anchorage from steel pipe or tubing with 1/4-inch-thick steel plate welded to bottom of sleeve. Make sleeves not less than 8 inches deep and 3/4 inch larger than OD of bollard. Set bollards in sleeves with nonshrink grout.

C. Galvanize, prime, and paint bollards in accordance with Section 099600 "High-Performance Coatings."
2.11 ABRASIVE METAL NOSINGS

A. Extruded Units: Aluminum, with abrasive filler consisting of aluminum oxide, silicon carbide, or a combination of both, in an epoxy-resin binder. Fabricate units in lengths necessary to accurately fit openings or conditions.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. American Safety Tread Co., Inc.
   b. Armstrong Products, Inc.
   c. Balco, Inc.
   d. Wooster Products Inc.

2. Provide solid-abrasive-type units without ribs.
3. Nosings: Square-back units, complying with CBC Title 24 Chapter 11B for accessibility, for casting into concrete steps.

B. Provide anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.

C. Drill for mechanical anchors and countersink. Locate holes not more than 4 inches from ends and not more than 12 inches o.c., evenly spaced between ends, unless otherwise indicated. Provide closer spacing if recommended by manufacturer.

1. Provide two rows of holes for units more than 5 inches wide, with two holes aligned at ends and intermediate holes staggered.

D. Apply clear lacquer to concealed surfaces of extruded units.

2.12 LOOSE BEARING AND LEVELING PLATES

A. Provide loose bearing and leveling plates for steel items bearing on masonry or concrete construction. Drill plates to receive anchor bolts and for grouting.

B. Galvanize exterior plates.

C. Prime interior plates with primer specified in Section 099113 "Interior Painting."

2.13 LOOSE STEEL LINTELS

A. Fabricate loose steel lintels from steel angles and shapes of size indicated for openings and recesses in masonry walls and partitions at locations indicated. Fabricate in single lengths for each opening unless otherwise indicated. Weld adjoining members together to form a single unit where indicated.

B. Size loose lintels to provide bearing length at each side of openings equal to 1/12 of clear span, but not less than 8 inches unless otherwise indicated.

C. Galvanize, prime, and paint exposed loose steel lintels located in exterior walls.
2.14 STEEL WELD PLATES AND ANGLES
   A. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with no fewer than two integrally welded steel strap anchors for embedding in concrete.

2.15 FINISHES, GENERAL
   A. Finish metal fabrications after assembly.
   B. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.

2.16 STEEL AND IRON FINISHES
   A. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A 153/A 153M for steel and iron hardware and with ASTM A 123/A 123M for other steel and iron products.
      1. Hot-dip galvanize exterior steel fabrications.
      2. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
   B. Preparation for Shop Priming Galvanized Items: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with metallic phosphate process.
   C. Shop prime iron and steel items not indicated to be galvanized unless they are to be embedded in concrete, sprayed-on fireproofing, or masonry, or unless otherwise indicated.
      1. Shop prime with universal shop primer unless zinc-rich primer is indicated.
   D. Preparation for Shop Priming: Prepare surfaces to comply with requirements indicated below:
      2. Items Indicated to Receive Primers Specified in Section 09960 "High-Performance Coatings": SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
      3. Other Items: SSPC-SP 3, "Power Tool Cleaning."
   E. Shop Priming: Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.
      1. Stripe paint corners, crevices, bolts, welds, and sharp edges.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL
   A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

C. Field Welding: Comply with the following requirements:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.

E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

F. Corrosion Protection: Coat concealed surfaces of aluminum that come into contact with grout, concrete, masonry, wood, or dissimilar metals with the following:
   1. Cast Aluminum: Heavy coat of bituminous paint.
   2. Extruded Aluminum: Two coats of clear lacquer.

3.2 INSTALLING MISCELLANEOUS FRAMING AND SUPPORTS

A. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings.

3.3 INSTALLING METAL BOLLARDS

A. Fill metal-capped bollards solidly with concrete and allow concrete to cure seven days before installing.

B. Anchor bollards in concrete with pipe sleeves preset and anchored into concrete. Fill annular space around bollard solidly with nonshrink grout; mixed and placed to comply with grout manufacturer's written instructions. Slope grout up approximately 1/8 inch toward bollard.

C. Place removable bollards over internal sleeves and secure with 3/4-inch machine bolts and nuts. After tightening nuts, drill holes in bolts for inserting padlocks. District furnishes padlocks.

D. Fill bollards solidly with concrete, mounding top surface to shed water.

3.4 INSTALLING NOSINGS

A. Center nosings on tread widths unless otherwise indicated.
B. For nosings embedded in concrete steps or curbs, align nosings flush with riser faces and level with tread surfaces.

3.5 INSTALLING BEARING AND LEVELING PLATES


1. Set bearing and leveling plates on wedges, shims, or leveling nuts. After bearing members have been positioned and plumbed, tighten anchor bolts. Do not remove wedges or shims but, if protruding, cut off flush with edge of bearing plate before packing with nonshrink grout. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.

3.6 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

1. Apply by brush or spray to provide a minimum 2.0-mil dry film thickness.

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780/A 780M.

3.7 FINISH SCHEDULE FOR METAL FABRICATIONS

A. Exterior Steel:

1. Galvanize exterior steel, typical, unless otherwise indicated.
2. Where indicated, shop prime galvanized steel with galvanized steel primer and paint in accordance with Section 099113 "Exterior Painting." Do not prime or paint exterior galvanized steel where indicated.
   a. Galvanize, prime, and paint exterior steel handrails with epoxy paint and polyurethane topcoat in accordance with Section 099600 "High-Performance Coatings."

B. Interior Steel:

1. Where indicated, shop prime exposed steel with universal primer and paint in accordance with Section 099123 "Interior Painting."
   a. Prime and paint interior steel handrails with epoxy paint and polyurethane topcoat in accordance with Section 099600 "High-Performance Coatings."
2. Steel concealed in wall or ceiling assemblies and not exposed may remain unfinished.

END OF SECTION
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Preassembled service class steel stairs with concrete-filled treads.
   2. Abrasive nosings.

B. Related Requirements:
   1. Section 033000 "Cast-in-Place Concrete" for concrete fill for stair treads and platforms.
   2. Section 055119 "Metal Grating Stairs" for exposed roof mounted metal stairs.
   3. Section 055213 "Pipe and Tube Railings" for steel tube railings attached to metal stairs and for steel tube handrails attached to walls adjacent to metal stairs.
   4. Section 057100 "Decorative Metal Stairs" for Architectural class stairs with precast concrete treads.

1.3 RELATED WORK

A. Refer to Section 055000 "Metal Fabrications" for materials and finishes not noted in this Section that apply to the work of this Section.

1.4 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorages for metal stairs. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

C. Coordinate locations of hanger rods and struts with other work so that they do not encroach on required stair width and are within the fire-resistance-rated stair enclosure.

1.5 ACTION SUBMITTALS

A. Product Data: For metal pan stairs and the following:
   1. Abrasive nosings.
B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

D. Samples for Verification: For each type and finish of nosing and tread finish.

1.6 INFORMATIONAL SUBMITTALS

A. Evaluation Reports:
   1. For anchors, from ICC-ES, or equivalent.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

B. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Provide the following upon request:
   1. Fabricator qualifications.
   2. Welding certificates.
   3. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance of Stairs: Refer to Drawings. Metal stairs have been designed to withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
   1. Uniform Load: 100 lbf/sq. ft.
   2. Concentrated Load: 300 lbf applied on an area of 4 sq. in.
   3. Uniform and concentrated loads are not assumed to act concurrently.
   4. Stair Framing: Capable of withstanding stresses resulting from railing loads in addition to loads specified above.
   5. Deflection of treads, platforms, and framing members limited to L/360 or 1/4 inch, whichever is less.

B. Structural Performance of Railings: Refer to Section 057300 “Decorative Metal Railings,” including attachments to metal stairs.

C. Seismic Performance of Stairs: Metal stairs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
2.2 METAL STAIRS, GENERAL

A. NAAMM Stair Standard: Comply with "Recommended Voluntary Minimum Standards for Fixed Metal Stairs" in NAAMM AMP 510, "Metal Stairs Manual," Service class, unless more stringent requirements are indicated.

2.3 METALS

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For components exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

C. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

D. Steel Tubing: ASTM A 500 (cold formed), Grade B or ASTM A 513.

E. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.

F. Uncoated, Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, either commercial steel, Type B, or structural steel, Grade 25, unless another grade is required by design loads; exposed.

G. Uncoated, Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, either commercial steel, Type B, or structural steel, Grade 30, unless another grade is required by design loads.

2.4 ABRASIVE NOSINGS

A. Extruded Units: Aluminum units with full-abrasive filler consisting of aluminum oxide, silicon carbide, or a combination of both, in an epoxy-resin binder.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Model N2.25E as manufactured by Nystrom, Inc., or comparable product by one of the following, or by Architect approved equal:
   a. American Safety Tread Co., Inc.
   b. Amstep Products.
   c. Armstrong Products, Inc.
   d. Babcock-Davis.
   e. Balco, A CSW Industrials Co.

2. California Title 24 compliant.


4. Anchor: Provide integral extruded anchors for embedding units in concrete-filled steel pan stair treads as standard with manufacturer; minimum 5/8-inch deep.

5. Base Finish: Mill

6. Length: Fabricate units in lengths necessary to accurately fit openings or conditions, less 1/8-inch clearance on each end.

7. Apply clear lacquer to concealed surfaces of extruded units set into concrete.

8. Color: As selected by Architect from manufacturer's complete line of colors.

B. Apply clear lacquer to concealed surfaces of extruded units set into concrete.
2.5 FASTENERS

A. Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A; with hex nuts, ASTM A 563; and, where indicated, flat washers.

B. Anchor Bolts: ASTM F 1554, Grade 36, threaded carbon-steel hex-headed bolts or headless bolts, with encased end threaded of dimensions indicated; with carbon-steel nuts, ASTM A 563; and, where indicated, flat hardened-steel washers; zinc coated by hot-dip process according to ASTM A 153/A 153M, Class C.

C. Post-Installed Anchors: Torque-controlled expansion anchors according to ICC-ES AC193, or chemical anchors
   1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941, Class Fe/Zn 5, unless otherwise indicated.
      a. Product: Refer to Drawings.

2.6 MISCELLANEOUS MATERIALS

A. Shop Primers: Provide rust-inhibitive primers and paints that comply with Section 099123 "Interior Painting."

B. Cast-in-Place Concrete Treads:
   1. Concrete Materials and Properties: Comply with requirements in Section 033000 "Cast-in-Place Concrete" for normal-weight, air-entrained, ready-mix concrete with minimum 28-day compressive strength of 3000 psi and maximum aggregate size of 1/2 inch unless otherwise indicated.
   2. Plain Steel Welded-Wire Reinforcement: ASTM A 1064/A 10645M, galvanized steel, 6 by 6 inches, W1.4 by W1.4, unless otherwise indicated on Drawings.
   3. Reinforcement Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening welded-wire reinforcement in place.
      b. For galvanized reinforcement, use galvanized wire or dielectric-polymer-coated wire bar supports.

2.7 FABRICATION, GENERAL

A. Provide complete stair assemblies, including metal framing, hangers, struts, railings, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.
   1. Join components by welding unless otherwise indicated.
   2. Use connections that maintain structural value of joined pieces.

B. Preassembled Stairs: Assemble stairs in shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
D. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

E. Form exposed work with accurate angles and surfaces and straight edges.

F. Weld connections to comply with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Weld exposed corners and seams continuously unless otherwise indicated.
   5. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Type 3 welds: partially dressed weld with spatter removed.

G. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) screws or bolts unless otherwise indicated. Locate joints where least conspicuous.

H. Embed stair nosings into concrete treads so that top of abrasive resin insert is less than 1/16 inch above top of tread. Comply with CBC Title 24 Chapter 11B requirements for placement.

I. Finish cast-in-place concrete treads as indicated.

2.8 STEEL-FRAMED STAIRS

A. Stair Framing:
   1. Fabricate stringers of steel as indicated.
      a. Provide closures for exposed ends of stringers.
   2. Construct platforms of steel headers and miscellaneous framing members as indicated.
   3. Weld or bolt stringers to headers; weld or bolt framing members to stringers and headers.
      If using bolts, fabricate and join so bolts are not exposed on finished surfaces.
   4. Where stairs are enclosed by gypsum board assemblies, provide hanger rods or struts to support landings from floor construction above or below. Locate hanger rods and struts where they do not encroach on required stair width and are within the fire-resistance-rated stair enclosure.

B. Metal Pan Stairs: Form risers, subtread pans, and subplatforms to configurations shown from steel sheet of thickness indicated.
   1. Steel Sheet: Uncoated cold- or hot-rolled steel sheet.
   2. Directly weld metal pans to stringers; locate welds on top of subtreads where they are concealed by concrete fill or attach risers and subtreads to stringers with brackets made of steel angles or bars. Weld brackets to stringers and attach metal pans to brackets by welding, riveting, or bolting. Do not weld risers to stringers.
   3. Attach abrasive nosings to risers.
   4. At Contractor's option, provide stair assemblies with metal pan subtreads filled with reinforced concrete during fabrication.
   5. Provide subplatforms of configuration indicated or, if not indicated, the same as subtreads. Weld subplatforms to platform framing.
2.9 STAIR RAILINGS

A. Comply with applicable requirements in Section 055213 "Pipe and Tube Railings."
   1. Connect posts to stair framing by direct welding unless otherwise indicated.

2.10 FINISHES

A. Finish metal stairs after assembly.

B. Preparation for Shop Priming: Prepare uncoated ferrous-metal stair surfaces to comply with the following:
   2. Exposed metal to receive primers specified in Section 099123 "Interior Painting": SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."

C. Apply shop primer to uncoated surfaces of metal stair components, except those with galvanized finishes and those to be embedded in concrete or masonry unless otherwise indicated. Comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.

D. Shop-Primed and Field-Painted Finish: Comply with primers and paints specified in Section 099123 "Interior Painting," as indicated.
   1. Color: As selected by Architect from paint manufacturer's full range.

PART 3 - EXECUTION

3.1 INSTALLING METAL PAN STAIRS

A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.

B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.

C. Install metal stairs by welding stair framing to steel structure or to weld plates cast into concrete unless otherwise indicated.

D. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

E. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

F. Field Welding: Comply with requirements for welding in "Fabrication, General" Article.

G. Place and finish concrete fill for treads and platforms to comply with Section 033000 "Cast-in-Place Concrete."
1. Install abrasive nosings with anchors fully embedded in concrete. Center nosings on tread width.

3.2 INSTALLING RAILINGS

A. Adjust railing systems before anchoring to ensure matching alignment at abutting joints. Space posts at spacing indicated or, if not indicated, as required by design loads. Plumb posts in each direction. Secure posts and rail ends to building construction as follows:

1. Anchor posts to steel by welding or bolting to steel supporting members.

3.3 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

1. Apply by brush or spray to provide a minimum 2.0-mil dry film thickness.

B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Section 099113 "Exterior Painting," Section 099123 "Interior Painting," and Section 099600 "High-Performance Coatings."

END OF SECTION
SECTION 055119 - METAL GRATING STAIRS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes roof-mounted metal stairs with steel-grating treads and closed metal risers.

B. Related Requirements:
   1. Section 055213 "Pipe and Tube Railings" for steel tube railings attached to metal grating stairs and for steel tube handrails attached to walls adjacent to metal stairs.

1.3 COORDINATION

A. Coordinate roof mounted supports with flashing and roof membrane installation.

B. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written instructions to ensure that shop primers and topcoats are compatible with one another.

1.4 ACTION SUBMITTALS

A. Product Data: For metal grating stairs and the following:
   1. Premanufactured tread products.
   2. Paint products.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

B. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Provide the following upon request:
   1. Installer qualifications.
   2. Welding certificates.
3. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance of Stairs: Metal stairs have been designed withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
   1. Uniform Load: 100 lbf/sq. ft.
   2. Concentrated Load: 300 lbf applied on an area of 4 sq. in.
   3. Uniform and concentrated loads need not be assumed to act concurrently.
   4. Stair Framing: Capable of withstanding stresses resulting from railing loads in addition to loads specified above.
   5. Limit deflection of treads, platforms, and framing members to L/360.

B. Seismic Performance of Stairs: Metal stairs withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.2 METALS

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For components exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

C. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

D. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from plate complying with ASTM A 36/A 36M or ASTM A 283/A 283M, Grade C or D.

E. Steel Bars for Grating Treads: ASTM A 1011 or ASTM A 1018.

F. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.

2.3 FASTENERS

A. General: Provide zinc-plated fasteners with coating complying with ASTM B 633 or ASTM F 1941, Class Fe/Zn 12 for exterior use.

B. Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A; with hex nuts, ASTM A 563; and, where indicated, flat washers.
2.4 MISCELLANEOUS MATERIALS

A. Shop Primers and Paints: Provide primers and paints that comply with Section 099113 "Exterior Painting" for galvanized steel.
   1. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish paint systems indicated.

B. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

2.5 FABRICATION, GENERAL

A. Provide complete stair assemblies, including metal framing, hangers, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.
   1. Join components by welding unless otherwise indicated.
   2. Use connections that maintain structural value of joined pieces.

B. Form exposed work with accurate angles and surfaces and straight edges.

C. Weld connections to comply with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Weld exposed corners and seams continuously unless otherwise indicated.
   5. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Type 4 welds: good quality, uniform undressed weld with minimal splatter.

D. Fabricate joints that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

2.6 STEEL-FRAMED STAIRS

A. NAAMM Stair Standard: Comply with "Recommended Voluntary Minimum Standards for Fixed Metal Stairs" in NAAMM AMP 510, "Metal Stairs Manual," Service Class, unless more stringent requirements are indicated.

B. Stair Framing:
   1. Fabricate stringers of steel as indicated.
   2. Construct platforms of steel headers and miscellaneous framing members as needed to comply with performance requirements.
   3. Weld or bolt stringers to headers; weld or bolt framing members to stringers and headers.
   4. Risers: Rolled steel floor plate.
   5. Finish: Galvanized and prepared for field painting.

C. Metal Bar-Grating Stair Treads: Form treads and platforms to configurations shown from metal bar grating; fabricate to comply with NAAMM MBG 531, "Metal Bar Grating Manual."
   1. ADA-Compliant: Fabricate treads and platforms from welded steel grating with openings in gratings no more than 1/2 inch in least dimension.
2. Basis-of-Design Product: Subject to compliance with requirements, provide Algrip Slip Resistant Metal Bar Grating by Grating Pacific, Inc., or Architect approved equal by one of the listed manufacturers.
   a. Grating shall be type "W" Welded Steel Grating manufactured with A-1011 Carbon Steel. Bar spacing shall be type 11-4 (bearing bars spaced at maximum 11/16 inch on center and cross bars spaced at 4 inches on center).
   b. Bearing bar size: 1-1/2 inch by 3/16 inch up to 54 inch span. Provide 1-3/4 inch by 3/16 inch bar size for spans over 48 inches, or provide intermediate tread support.
   c. Surface: Slip-resistant.

3. Finish: Galvanized and prepared for field finishing.

4. Fabricate grating treads with rolled-steel floor plate nosing and with steel angle or steel plate carrier at each end for stringer connections. Secure treads to stringers with bolts as indicated.

5. Fabricate grating platforms with nosing matching that on grating treads. Provide toeplates at open-sided edges of grating platforms. Weld grating to platform framing.

6. Other acceptable manufacturers: Subject to compliance with requirements, provide comparable products by one of the following:
   a. McNichols
   b. Grainger
   c. P&R Metals, Inc.

2.7 STAIR RAILINGS

A. Comply with applicable requirements in Section 055213 "Pipe and Tube Railings."
   1. Connect posts to stair framing by direct welding unless otherwise indicated.

2.8 FINISHES

A. Finish metal stairs after assembly.

B. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A 153/A 153M for steel and iron hardware and with ASTM A 123/A 123M for other steel and iron products.
   1. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
   2. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.

C. Preparation for Shop Priming: Prepare surfaces to comply with requirements indicated below:
   1. Galvanized Items: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner or metallic phosphate prior to priming.

D. Primer Application: Apply shop primer to prepared surfaces of railings unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Shop, Field, and Maintenance Painting of Steel."
   1. Stripe paint corners, crevices, bolts, welds, and sharp edges.

E. Repairing Galvanized Surfaces: Clean welds and abraded areas and repair galvanizing to comply with ASTM A 780/A 780M.
F. Shop-Primed and Field-Painted Finish: Comply with primer and paints specified in Section 099113 "Exterior Painting," as indicated for steel framing, treads and risers, brackets and supports.

1. Color: As selected by Architect from paint manufacturer's full range.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.

B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.

C. Field Welding: Comply with requirements for welding in "Fabrication, General" Article.

D. Attach to roof structural supports as indicated.

E. Provide metal flashing at post base supports feathered into roof membrane and seal roof penetrations watertight.

F. Paint stairs in accordance with Section 09 9113 "Exterior Painting."

3.2 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

1. Apply by brush or spray to provide a minimum 2.0-mil dry film thickness.

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780/A 780M.

END OF SECTION
SECTION 055213 - PIPE AND TUBE RAILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Steel tube railings and handrails.

B. Related Requirements:
   1. Section 055112 "Metal Pan Stairs" for interior service-class metal stairs on which to mount tube railings.
   2. Section 055119 "Metal Grating Stairs" for exterior metal stairs on which to mount tube railings.
   3. Section 057300 "Decorative Metal Railings" for ornamental railings.

1.3 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

C. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not satisfy structural performance requirements.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Railing brackets.
   2. Grout, anchoring cement, and paint products.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

D. Samples: For each type of exposed finish required.
   1. Sections of each distinctly different linear railing member, including handrails, top rails, posts, and balusters.
2. Fittings and brackets.

1.5 INFORMATIONAL SUBMITTALS

A. Evaluation Reports:
   1. For anchors, from ICC-ES, or equivalent.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

B. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Provide the following upon request:
   1. Fabricator qualifications.
   2. Welding certificates.
   3. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.
   4. Product Test Reports: For pipe and tube railings, for tests performed by a qualified testing agency, according to ASTM E 894 and ASTM E 935.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

1.8 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 METALS, GENERAL

A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.
   1. Provide post-mounted brackets and type of wall bracket with flange tapped for concealed anchorage to threaded hanger bolt and that provides 1-1/2-inch clearance from inside face of handrail to finished wall surface.
2.2 STEEL AND IRON

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Tubing: ASTM A 500, cold-formed steel tubing, Grade C.

C. Plates, Shapes, and Bars: ASTM A 36.

2.3 FASTENERS

A. General: Provide the following:
   1. Ungalvanized Steel Railings: Plated steel fasteners complying with ASTM B 633 or ASTM F 1941, Class Fe/Zn 5 for zinc coating.
   2. Hot-Dip Galvanized Railings: Type 304 stainless-steel or hot-dip zinc-coated steel fasteners complying with ASTM A 153/A 153M or ASTM F 2329 for zinc coating.
   3. Provide exposed fasteners with finish matching appearance, including color and texture, of railings.

B. Fasteners for Anchoring Railings to Other Construction: Refer to Drawings for type, grade, and class.

C. Fasteners for Interconnecting Railing Components:
   1. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless otherwise indicated.
   2. Provide tamper-resistant flat-head machine screws for exposed fasteners unless otherwise indicated.

D. Post-Installed Anchors: Torque-controlled expansion anchors according to ICC-ES AC193, or chemical anchors capable of sustaining, without failure, a load equal to 6 times the load imposed when installed in unit masonry and 4 times the load imposed when installed in concrete, as determined by testing according to ASTM E 488/E 488M, conducted by a qualified independent testing agency. Refer to Drawings for type and evaluation report number.
   1. Material for Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5, unless otherwise indicated.
      a. Product: Refer to Drawings.
      a. Product: Refer to Drawings.

2.4 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Etching Cleaner for Galvanized Metal: Complying with MPI#25.
C. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

D. Shop Primers: Provide primers that comply with Section 099600 "High-Performance Coatings."

E. Intermediate Coats and Topcoats: Provide products that comply with Section 099600 "High-Performance Coatings."
   2. Polyurethane Topcoat: Compatible with undercoat.

F. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.

G. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound.

2.5 FABRICATION

A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage.

B. Shop assemble railings to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

D. Form work true to line and level with accurate angles and surfaces.

E. Fabricate connections that are exposed to weather in a manner that excludes water. Provide weep holes where water may accumulate.

F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.

G. Connections: Fabricate railings with either welded or nonwelded connections unless otherwise indicated.

H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove flux immediately.
   4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.

I. Nonwelded Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.
1. Fabricate splice joints for field connection using an epoxy structural adhesive if this is manufacturer's standard splicing method.

J. Form Changes in Direction as Follows:
   1. By radius bends of radius indicated, or if not indicated by smallest radius without deformation of metal.

K. For changes in direction made by bending, use jigs to produce uniform curvature for each repetitive configuration required. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.

L. Close exposed ends of railing members with prefabricated end fittings.

M. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch or less.

N. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.
   1. At brackets and fittings fastened to gypsum board partitions, provide crush-resistant fillers or other means to transfer loads through wall finishes to structural supports and prevent bracket or fitting rotation and crushing of substrate.

O. For interior railing posts set in concrete, provide steel sleeves not less than 6 inches long with inside dimensions not less than 1/2 inch greater than outside dimensions of post, with metal plate forming bottom closure.

2.6 STEEL AND IRON FINISHES

A. Galvanized Railings:
   1. Hot-dip galvanize exterior indicated steel railings, including hardware, after fabrication.
   2. Comply with ASTM A 123/A 123M for hot-dip galvanized railings.
   4. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
   5. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.

B. For galvanized railings, provide hot-dip galvanized fittings, brackets, fasteners, sleeves, and other ferrous components.

C. Preparation for Shop Priming of Metal Railings: Prepare surfaces to comply with requirements indicated below:
   1. Galvanized Items: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner or metallic phosphate prior to priming.
   2. Items indicated to receive primers specified in Section 099600 "High-Performance Coatings": SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
   3. Other Items: SSPC-SP 3, "Power Tool Cleaning."

D. Shop prime steel items not indicated to be galvanized unless they are to be embedded in concrete, masonry, or unless otherwise indicated.

E. Shop prime with primers specified in Section 099600 "High-Performance Coatings."
F. Primer Application: Apply shop primer to prepared surfaces of railings unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Shop, Field, and Maintenance Painting of Steel."

1. Stripe paint corners, crevices, bolts, welds, and sharp edges.

G. Steel Railing and Handrail Finishes: Shop-primed and shop-coated finish complying with coating specified in Section 099600 "High-Performance Coatings," as indicated.

1. Apply epoxy intermediate and polyurethane topcoats to prime-coated surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Shop, Field, and Maintenance Painting of Steel." Apply at spreading rates recommended by coating manufacturer.

2. Color: As selected by Architect from coating manufacturer's full range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine gypsum board assemblies, where reinforced to receive anchors, to verify that locations of concealed reinforcements are clearly marked for Installer. Locate reinforcements and mark locations if not already done.

3.2 INSTALLATION, GENERAL

A. Fit exposed connections together to form tight, hairline joints.

B. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.

1. Do not weld, cut, or abrade surfaces of railing components that are coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.

2. Set posts plumb within a tolerance of 1/16 inch in 3 feet.

3. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet.

C. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

D. Adjust railings before anchoring to ensure matching alignment at abutting joints.

E. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.3 RAILING CONNECTIONS

A. Nonwelded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Seal recessed holes of exposed locking screws using plastic cement filler colored to match finish of railings.
B. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.

C. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches of post.

3.4 ANCHORING POSTS

A. When installing posts in concrete, use metal sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions.

B. Weld posts to metal stair framing as indicated and cover with oval flanges connected to posts and to metal supporting members as follows:
   1. For steel pipe railings, weld flanges to post and bolt to metal supporting surfaces.

3.5 ATTACHING RAILINGS

A. Attach handrails to wall with wall brackets and to railing posts with post brackets. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.

B. Secure wall brackets and railing end flanges to building construction as follows:
   1. For steel-framed partitions, use fasteners as indicated in Drawings installed through flanges of steel framing or through concealed steel reinforcements.

3.6 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting to comply with SSPC-PA 1 requirements for touching up shop-painted surfaces.
   1. Apply by brush or spray to provide a minimum 2.0-mil dry film thickness.

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas, and repair galvanizing to comply with ASTM A 780/A 780M.

3.7 PROTECTION

A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.

END OF SECTION
SECTIO N 057005 - LANDSCAPE METALWORK

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide all labor, materials and equipment as required for complete, finished installation of metalwork as shown on the drawings and specified including the following items:
   1. Railings and Guardrails
   2. Miscellaneous landscape metal

B. Metal fabrication includes plates, bars, strips, tubes, pipes and castings made from iron and steel that are not specifically listed herein.

1.2 Related requirements specified elsewhere include:

A. Section 312300, SUBGRADE PREPARATION AND BASE MATERIAL

B. Section 321312, SITE CONCRETE

1.3 REFERENCES AND STANDARDS

A. "Code for Arc and Gas Welding in Building Construction" of American Welding Society, AWSD1.1, latest edition, with current supplements and addenda, is hereby made a part of this Section and miscellaneous metalwork shall conform to the applicable requirements therein, except as otherwise specified herein or shown on the drawings. Nothing contained herein shall be construed as permitting work that is contrary to code requirements or governing rules and regulations.

B. All work shall conform to the American Institute of Steel Construction Specifications for design, erection and fabrication, and acceptable standards of good practice. Finished members shall be true to line and free from twists and bends.

C. SSPC "Steel Structures Painting Manual, Volume 2, Systems and Specifications".


1.4 SUBMITTALS, per Section 013300

A. Product Data: Furnish manufacturer’s literature including paint, grout and recommendations for cleaning.

B. Shop Drawings: Provide shop drawings of all handrails, guardrails, and railings. Shall show dimensions, sizes, thicknesses, gauges, finishes, joining attachments and relationship of work to adjoining construction. Where items must fit and coordinate with finished surfaces and/or constructed spaces, take measurements at site and not from drawings. Where concrete, masonry or other materials must be set to exact locations to receive work, furnish assistance and directions necessary to permit other trades to properly locate their work. Where welded connectors, concrete or masonry inserts are required to receive work, shop drawings shall
show exact locations required, and all such drawings shall be furnished to the trades responsible for installing the connectors or inserts. Catalogue work sheets showing illustrated cuts of item to be furnished, scale details and dimensions may be submitted for standard manufactured items. 

1. Provide templates for anchorage installations by others.

C. Samples: Furnish finish samples of uncoated steel anchor and bolts for farm machinery, etc.

D. Certificates: Submit certification signed by California registered civil or structural engineer indicating compliance with Contract Documents and code requirements where required.

1.5 SYSTEM DESCRIPTION

A. Rail Regulatory Requirements:
   2. Building Code: Comply with requirements of applicable building codes for railing design, except where more restrictive codes are specified.

1.6 QUALITY ASSURANCE

A. Fabricator Qualifications: Firm with minimum five years successful experience fabricating metal items similar to those required for Project.

PART 2 - MATERIALS

2.1 BASIC MATERIALS AND ACCESSORIES

A. Steel Tubing: ASTM A500 (cold-formed), Minimum Grade B, seamless where exposed.

B. Steel Pipe: ASTM A53, Type S, seamless, Grade A, minimum standard weight, STD or Schedule 40, unless otherwise noted.


D. Bolts: Structural grade steel, ASTM A307-(latest edition), with suitable hex nuts and washers, all galvanized except where noted otherwise.
E. Concrete Inserts: Threaded or wedge type; galvanized ferrous castings, either malleable iron ASTM A47 or cast steel ASTM A27. Provide bolts, washers and shims as required, hot-dip galvanized, ASTM A153.

F. Fasteners and Rough Hardware: Type as required for specific usage; provide galvanized zinc-coated fasteners for exterior use or where built into exterior walls.

G. Welding Materials: AWS D1.1, type required for materials being welded.

H. Stainless Steel
1. Plate, Sheet and Strip: ASTM A167, Type 302 or Type 304. Provide mill finish unless otherwise shown.
2. Bars and Shapes: ASTM A276, Type 304. Provide mill finish unless otherwise shown.
3. Tubing: ASTM A269
4. Stainless Steel Railing Finishes: Submit finish sample for approval. Remove tool and die marks and stretch lines or blend into finish. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated free of cross scratches. Run grain with long dimension of each piece.
5. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

I. Castings: Gray iron, ASTM A 48, Class 30; malleable iron, ASTM A 47.

J. Screws: Stainless Steel and Galvanized zinc, electro-plated or brass.

K. Welding Electrodes: As permitted by AWS D1.1

L. Galvanizing:
1. Galvanize fabricated items as shown and specified after fabrication in accordance with ASTM A123-09.
2. Parts shall be made in suitable sections. First clean in a hot pickling bath to remove scale and then rinse clean with clear water. After pickling and washing, dip parts in liquid zinc tank sufficient length of time to heat parts to zinc temperature, then remove and allow to drip and cool; straighten as required.

M. Non-Metallic Shrinkage Resistant Grout: Premixed, nonmetallic, non-corrosive, non-staining, shrinkage resistant product containing selected silica sands, Portland cement, shrinkage compensating agents, plasticizing and water-reducing agents, complying with CE-CRD-C621 and ASTM C1107, free of gas-producing or gas-releasing agents, oxidizing catalysts, inorganic accelerators and chlorides. Provide one of the following:
1. "Five Star Grout" (U.S. Grout Corp.).
2. "Masterflow 713" (Master Builders Co.).
3. "Crystex" (L&M Construction Chemicals, Inc.).

N. Fasteners and Anchorage Devices: Provide fasteners complying with the requirements of Industrial Fasteners Institute standards. Type, grade, class and style best suited for the respective purpose. Use countersunk flat-head Phillips type machine screws for exposed fasteners, except where Allen head screws are required. Use galvanized steel or stainless steel fasteners for exterior construction and for fastening components fabricated of galvanized steel except where specified otherwise. Fasteners exposed in finish surfaces to match finish of adjacent surfaces.

O. Component Connections: Refer to Drawings.
P. Material Selection: Select materials for straightness, free of defects and irregularities.
   1. Exposed-to-view surfaces exhibiting pitting, seam marks, roller marks, "oil canning", stains, discolorations, and imperfections on finished units are not acceptable.

Q. Joints: Make exposed joints flush butt type, hairline joints where mechanically fastened; provide concealed connection devices with hidden fasteners.
   1. Fabricate continuous items with joints neatly fitted and secured.
   2. Ease exposed edges to approximate 1/32" uniform radius.
   3. Fabricate joints exposed to weather in manner to exclude water or provide weep holes where water could accumulate.

R. Welding: Comply with AWS for recommended practices in welding each type of material; provide welds behind finished surfaces without distortion or discoloration on exposed side; dress exposed and contact surfaces.

S. Exposed Mechanical Fastenings: Flush countersunk fasteners unobtrusively located, consistent with design of structure.

T. Assemblage: fit and shop assemble in largest practical sections for site delivery.

U. Dissimilar Materials: Separate dissimilar materials with bituminous paint where concealed, with preformed separators, or similar method to prevent corrosion.

2.2 SPECIALLY FABRICATED PRODUCTS

A. Railings and Handrails: Make all bar railings of milled steel unless noted otherwise; all connections welded. Where pipe railing are required, make from (1-1/2) outside diameter seamless steel pipe unless noted otherwise. Fabricate in largest sections feasible; all shop joints welded; all field joints with concealed sleeves and pins.
   1. 1.5" O.D. Stainless Steel Tube HSS1 1/2x0.12
   2. 1.5" I.D (1.9" O.D) Stainless Steel Extra Strong Pipe

B. Railings and Handrails Design: Continuous railings conforming to applicable code and design requirements. Construct to support a concentrated load of 250 lbs. Applied at any point and in any direction and for a uniform load of 50 lbs. Per foot applied in any direction. The concentrated and uniform loading conditions shall not be applied simultaneously.

2.3 SHOP PAINTING

A. General:
   1. Shop paint miscellaneous metal work, except members or portions of members to be embedded in concrete or masonry, surfaces and edges to be field welded unless otherwise specified.
   2. Remove oil, grease and similar contaminants in accordance with SSPC SP-1 "Solvent Cleaning", prior to any additional surface preparation specified.
   3. Clean and prepare metal surfaces before applying shop coat. Remove rust and mill scale in accordance with SSPC SP-3 "Power Tool Cleaning".
   4. Immediately after surface preparation, apply primer in accordance with manufacturer's instructions. Use painting methods which will result in full coverage and dry film thickness specified.
5. Apply one shop coat of primer to fabricated metal items, except apply 2 coats of primer to surfaces inaccessible after assembly or erection. In addition, apply one shop coat of finish paint to entire surfaces of exterior loose lintels, shelf and relieving angles, dunnage and other items as noted or specified. Change color of second or finish coat to distinguish it from the first coat.

6. Separate dissimilar metals with one coat of dielectric separator. Do not extend coating onto exposed or finished surfaces.

7. Application: Do not paint when ambient temperature is below 40°F. Paint in dry weather or under cover; paint over dry rust-free surfaces. Stir paint and keep at uniform consistency during application. Apply paint by brush or spray per manufacturer's directions to a dry film thickness of not less than 1.5 mils (approximately 370-375 SF of surface per gallon); do not thin paint in excess of manufacturer's recommendations. Allow paint to dry before handling or shipment.

B. Fully Concealed Items:
1. Clean steel work by "Solvent Cleaning" method specified in SSPC-SP 1, followed by "Hand Tool Cleaning" to remove loose mill scale and rust by methods specified in SSPC-SP 2.
2. Apply ferrous metal primer immediately after cleaning to uniform dry film thickness of 2.0 mils.
3. Apply second coat of same primer and same thickness on concealed work which will be built into below grade work, or will be concealed in areas designated high humidity areas.

C. Exposed Exterior Items:
1. Apply the following cleaning, treatment and painting to exterior work which will be fully exposed or only partially exposed, and to exposed interior work in areas designated as high humidity areas.
2. Clean by "Solvent Cleaning" method specified in SSPC-SP 1, followed by "Power Tool Cleaning" to remove loose mill scale and rust by methods specified in SSPC-SP 3, followed by "Pickling" to remove remaining mill scale and rust by methods specified in SSPC-SP 8. Power tool cleaning and pickling may be omitted from work fabricated from cold-rolled or cold-finished stock, and from castings, provided surfaces are not heavily rusted.
3. Apply pretreatment as recommended by ferrous metal primer manufacturer.
4. Apply prime coat of ferrous metal primer immediately after pretreatment to uniform dry film thickness.

D. Preparation of Galvanized Metal Non-Ferrous Metal
1. Surface preparation:
   a. Existing galvanized metal: SSPC-SP1 Solvent Clean to remove visible and soluble surface contaminants.
   b. New galvanized metal shall be prepared per SSPC-SP16 Brush-Off Blast Cleaning of Non-Ferrous Metals to create a dense, uniform and angular surface profile of 1.0 to 1.5 mils. When abrasive blasting is not practical use power tools that create a surface profile (1.0 to 1.5 mils) and do not burnish the surface. The purpose is not to remove zinc but to roughen the surface. If zinc is removed to expose substrate, bare substrate must be primed with a zinc-rich primer such as Tnemec Series 94-H2O | Hydro-Zinc.
2. Surface clean cuts and welds to bright metal.
3. Prime Coat/Tie-Coat: Series 66HS Hi-Build Epoxoline; 2.0 – 3.0 mils DFT
4. Color Finish: Series 1075 Endura-Shield II; 2.0 – 3.0 mils DFT
5. Total DFT: 4.0 – 6.0 mils.

E. Preparation of Ferrous Metal
1. Surface preparation: SSPC-SP6/NACE No. 3 commercial blast clean to create a dense, uniform and angular anchor profile of 2.0 mils minimum.
2. Prime Coat: Series 94-H20 Hydro-Zine or Series 90-97 Tneme Zinc (meets Class B Slip for critical bolted connections); 2.5 – 3.5 mils DFT.
3. Field Touch-Up Primer: Series 94-H20 Hydro-Zinc; 2.5 – 3.5 mils DFT.
4. Striping Existing Metal: Series 66HS Hi-Build Epoxoline brush applied to all bare and corroded surfaces, sharp edges, welds, nuts and bolts per SSPC-PA 1, 6.6 Striping, 7.4.6 Application Method.
5. Intermediate Coat: Series 66HS Hi-Build Epoxoline; 4.0- 6.0 mils DFT.
6. Color Finish: Series 1075 Endura-Shield II; 3.0 – 5.0 mils DFT.
7. Total DFT: 9.5 – 14.5

PART 3 - EXECUTION

3.1 CONDITION OF SURFACES: Inspect all surfaces to receive site metal work and report all defects which would interfere with this installation. Starting work implies acceptance of surfaces as satisfactory.

3.2 FIELD MEASUREMENTS: Take field measurements prior to preparation of shop drawings and fabrication, where possible; do not delay job progress; allow for trimming and fitting where necessary.

3.3 WORKMANSHIP

A. Verify all measurements at job. Coordinate all metalwork with adjoining work for details of attachments, fittings, etc. Do all cutting, shearing, drilling, punching, threading, tapping, etc., required for site metalwork or for attachment of adjacent work. Drill or punch holes; do not use cutting torch. Shearing and punching shall leave true lines and surfaces. Obtain Owner’s Representative’s review prior to site cutting or making adjustments which are not part of scheduled work. Perform necessary cutting and altering for installation and coordination with other work.

B. Conceal all fastenings where feasible. Thickness of metal and details of assembly and supports shall give ample strength and stiffness. Form joints exposed to weather to exclude water.

C. Make all permanent connections in ferrous metal surfaces using welds where at all possible; do not use bolts or screws where they can be avoided.

D. Provide all lugs, clips, anchors, miscellaneous fastenings necessary for complete assembly and installation.

E. Set all work plumb, true, rigid, neatly trimmed out, accurately fitted and free from distortions or defects detrimental to appearance or performance. Miter corners and angles of exposed moldings and frames unless otherwise noted.

F. Set railings where shown set in sleeves or cored with quick-setting non-shrink anchor cement. Size sleeves for approximately 1/4" clearance all around.
G. Where items must be incorporated or built into adjacent work, deliver to trade responsible for such work in sufficient time that progress of work is not delayed. Be responsible for proper location of such items.

H. Make provisions for erection stresses by temporary bracing; Keep work in alignment.

I. Install ornamental metal items in accordance with manufacturer’s recommendations, installation instructions, and approved shop drawings.

J. Install items plumb, true and in correct relation to adjacent work, free from distortion or defects detrimental to appearance and performance.

K. Prior to securing continuous items, adjust to ensure proper matching at butt joints and correct alignment throughout their length.

L. Tolerances: Accurately align and locate components to required lines and levels to conform to following tolerances:
   1. Plumb: 1/8” in 10'-0”; ¼” in 40'-0”; non-cumulative.
   2. Level: 1/8” in 20'-0”; ¼” in 40'-0”; non-cumulative.
   3. Location: 3/8” maximum deviation from measured theoretical location (any member and location).

3.4 WELDING:

A. Perform all welding in accordance with AWS Code D1.1. Welds shall be made only by operators experienced in performing the type of work indicated. Welds normally exposed to view in the finished work shall be uniformly made and shall be ground smooth. Where welding is done in proximity to glass or finished surfaces, such surfaces shall be protected from damage due to weld sparks, spatter, or tramp metal.

B. Field Welding: Comply with AWS Welding Code for procedures related to field welding as related to appearance and quality of welds made and for methods used in correcting welding work. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals. Obtain fusion without undercut or overlap. Remove welding flux immediately. At exposed connections, finish exposed welds and surfaces smooth and blended so that no roughness shows after finishing and contour of welded surface matches those adjacent.

3.5 BOLTED, SCREWED AND RIVETED CONNECTIONS

A. In general, use bolts for field connections only and then only as detailed. Provide washers under all heads and nuts bearing on wood. Draw all nuts tight and nick threads of permanent connections to prevent loosening. Use beveled washers where bearing is on sloped surfaces.

B. Where screws must be used for permanent connections in ferrous metal, use flat-head-type, countersunk, with screw slots filled and finished smooth and flush.

C. Where rivets are used, they shall be machine-driven, tight, heads centered, countersunk, and finished flush and smooth.
3.6 SURFACE TREATMENT AND PROTECTIVE COATINGS

A. Cleaning: Thoroughly clean all mill scale, rust, dirt, grease and other foreign matter from ferrous metal prior to any galvanizing, hot phosphate treatment or painting. Conditions which are too severe to be removed by hand cleaning methods shall be cleaned per SSPC "Surface Preparation Specifications," "Solvent Cleaning, SSPC-SP-1"; "Power Tool Cleaning, SSPC-SP-3"; or "Brush-Off Blast Cleaning, SSPC-SP 7"; as required.

B. Exterior Ferrous Metal: Welds, burrs, and rough surfaces ground smooth and completed assembly cleaned, hot phosphate treated. Hot phosphate treatment not required on items which are not exposed in the finish work or on those items where size prohibits such treatment. Indicate on shop drawings where treatment is proposed to be omitted.

3.7 PAINTING

A. Prime Coat: After material has been properly cleaned and treated, apply two shop prime coats, each of a different color, to all surfaces except those encased in concrete or masonry. Apply all paint per manufacturer's directions. Spot paint all abrasions and field connections after assembly. Shop coats shall be dry prior to shipment to job site.

B. Finish Coats: Apply one coat per manufacturer's instructions. May be shop-applied where applicable.

3.8 GALVANIZING

A. Galvanize fabricated items after fabrication in accordance with ASTM A123-66.

B. Parts shall be made in suitable sections. First clean in a hot pickling bath to remove all scale and then rinse clean with clear water. After pickling and washing, dip parts in liquid zinc tank sufficient length of time to heat parts to zinc temperature, then remove and allow to drip and cool; straighten as required.

3.9 INSTALLATION

A. Coordinate and furnish anchorages, setting drawings, diagrams, templates, instructions and directions for installation of anchorages, including concrete inserts, sleeves, anchor bolts and other miscellaneous items having integral anchors that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to the project site. Deliver items which are to be built into the work of other Sections in time so as not to delay the progress of the Work.

B. Protect finished surfaces against damage during construction and remove protection at time of substantial completion.

C. Railings and Guardrails:

1. Anchor posts of railings into concrete by means of pipe sleeves preset and anchored into concrete. Set sleeves in concrete with tops flush with finish surface elevations and protect sleeves from water and concrete entry. After posts have been inserted into sleeves, solidly fill annular space between post and sleeve with non-shrink non-metallic grout. Cover anchorage joint with a round steel flange welded to post after placement of anchoring material.
2. Anchor posts to steel members with steel oval flanges, angle type or floor type as required by conditions, welded to posts and bolted to steel supporting members.

3. Mount handrails only on completed walls. Do not support handrails temporarily by any means not satisfying structural performance requirements. Mount handrails only on gypsum board assemblies reinforced to receive anchors. Adjust railings prior to anchoring to ensure matching alignment at abutting joints. Locate posts at spacing indicated, or if not indicated, at equal intervals as required by design loadings.

4. Secure handrails to wall with wall brackets and end fittings. Provide brackets of design shown, with flanges tapped for concealed anchorage and with not less than 1-1/2 in. clearance from inside face of handrail and finished wall surface. Located brackets as indicated, or if not indicated, at equal spacings as required by design loads.

D. Loose Plates: Prior to setting loose bearing and setting plates, clean concrete and masonry bearing surfaces of any bond reducing materials and roughen to improve bond to surfaces. Clean bottom surface of plates. Set on wedges or other adjustable devices. After members have been positioned and plumbed, tighten anchor bolts. do not remove wedges or shims, but if protruding, cut off flush with the edge of the plate before packing with grout. Pack grout solidly between bearing surfaces and plates to ensure no voids remain.

E. Immediately after erection, clean field welds, bolted connections, marred and abraded surfaces. Paint and touch-up paint with the specified paint system. Touch up galvanized surfaces in accordance with ASTM A780.

F. Replace items damaged in course of construction.

3.10 PROTECTION AND CLEANING, per Section 017400

A. Remove all soil and foreign matter from finished surface and apply such protective measures as may be required to prevent damage or discoloration of any kind until acceptance of project.

END OF SECTION
SECTION 057100 - DECORATIVE METAL STAIRS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes steel-framed decorative metal stairs with precast concrete treads.

B. Related Requirements:
   1. Section 051213 "Architecturally Exposed Structural Steel (AESS)" for finish requirements of decorative metal stairs.
   2. Section 055000 "Metal Fabrications" for miscellaneous steel fabrications and other metal items required for decorative metal stair installation.
   3. Section 057300 "Decorative Metal Railings" for metal railings attached to decorative metal stairs.

1.3 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorages for metal stairs. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.4 ACTION SUBMITTALS

A. Product Data: For metal stairs and the following:
   1. Abrasive nosings.
   2. Paint products.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

D. Samples for Initial Selection:
   1. For precast tread finish and color, and slip-resistant coatings, provide manufacturer’s available options.

E. Samples for Verification:
1. For finish metal work complying with AESS requirements for steel plate and welded joints; 12 inch long sample of finished pipe with welded joint in each AESS finish level required.
2. Sample: For precast concrete finish.
3. Sample: Full size sample of abrasive metal nosing by 6 inches long.

1.5 INFORMATIONAL SUBMITTALS

A. Evaluation Reports:
1. For anchors, from ICC-ES, or equivalent.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.
B. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
C. Provide the following upon request:
1. Fabricator qualifications.
2. Welding certificates.
3. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers certifying that shop primers are compatible with topcoats.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance of Stairs: Refer to Drawings. Metal stairs have been designed to withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
1. Uniform Load: 100 lbf/sq. ft.
2. Concentrated Load: 300 lbf applied on an area of 4 sq. in.
3. Uniform and concentrated loads are not assumed to act concurrently.
4. Stair Framing: Capable of withstanding stresses resulting from railing loads in addition to loads specified above.
5. Deflection of treads, platforms, and framing members limited to L/360 or 1/4 inch, whichever is less.

B. Structural Performance of Railings: Refer to Section 057300 "Decorative Metal Railings," including attachments to metal stairs.

C. Seismic Performance of Stairs: Metal stairs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
2.2 METAL STAIRS, GENERAL

A. NAAMM Stair Standard: Comply with "Recommended Voluntary Minimum Standards for Fixed Metal Stairs" in NAAMM AMP 510, "Metal Stairs Manual," Architectural class, unless more stringent requirements are indicated.

2.3 METALS

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For components exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

C. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

D. Uncoated, Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, either commercial steel, Type B, or structural steel, Grade 25, unless another grade is required by design loads; exposed.

2.4 FASTENERS

A. Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A; with hex nuts, ASTM A 563; and, where indicated, flat washers.

B. Anchor Bolts: ASTM F 1554, Grade 36, threaded carbon-steel hex-headed bolts or headless bolts, with encased end threaded of dimensions indicated; with carbon-steel nuts, ASTM A 563; and, where indicated, flat hardened-steel washers; zinc coated by hot-dip process according to ASTM A 153/A 153M, Class C.

C. Post-Installed Anchors: Torque-controlled expansion anchors according to ICC-ES AC193, or chemical anchors

1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941, Class Fe/Zn 5, unless otherwise indicated.
   a. Product: Refer to Drawings.

2.5 MISCELLANEOUS MATERIALS

A. Shop Primers: Provide rust-inhibitive primers that comply with Section 099600 "High-Performance Coatings."

B. Intermediate Coats and Topcoats: Provide products that comply with Section 099600 "High-Performance Coatings."

2. Polyurethane Topcoat: Compatible with undercoat.
2.6 PRECAST CONCRETE TREADS

A. Concrete Materials and Properties: Comply with requirements in Section 033000 "Cast-in-Place Concrete" for normal-weight, ready-mixed concrete with a minimum 28-day compressive strength of 5000 psi and a total air content of not less than 4 percent or more than 6 percent. Provide concrete inserts for inverted concealed bolted attachment to subtreads.
   1. Finish: As selected by Architect from precast manufacturer's available finishes and colors.
   2. Slip-Resistant Coating: Manufacturer's standard micro-grit; aluminum oxide or equivalent.

B. Reinforcement: Galvanized, welded wire reinforcement, 2 by 2 inches by 0.062-inch- diameter wire; comply with ASTM A 185/A 185M and ASTM A 82/A 82M, except for minimum wire size.

C. Abrasive Nosings: Extruded aluminum units with full-abrasive filler consisting of aluminum oxide, silicon carbide, or a combination of both, in an epoxy-resin binder.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Model N2.25E as manufactured by Nystrom, Inc., or comparable product by one of the following, or by Architect approved equal:
      a. American Safety Tread Co., Inc.
      b. Amstep Products.
      c. Armstrong Products, Inc.
      d. Babcock-Davis
      e. Balco, A CSW Industrials Co.
   2. California Title 24 compliant.
   4. Anchor: Provide integral extruded anchors for embedding units in concrete-filled steel pan stair treads as standard with manufacturer; minimum 5/8-inch deep.
   5. Base Finish: Mill
   6. Length: Fabricate units in lengths necessary to accurately fit openings or conditions, less 1/8-inch clearance on each end.
   7. Apply clear lacquer to concealed surfaces of extruded units set into concrete.
   8. Color: As selected by Architect from manufacturer's complete line of colors.

2.7 FABRICATION, GENERAL

A. Provide complete stair assemblies, including metal framing, hangers, struts, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.
   1. Join components by welding unless otherwise indicated.
   2. Use connections that maintain structural value of joined pieces.

B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges. Remove sharp or rough areas on exposed surfaces. Remove weld splatter.
   1. Refer to Section 051213 "Architecturally Exposed Structural Steel (AESS)" for finishing of steel stair components. Provide grading category of Grade AESS 3, or better.

C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

D. Form exposed work with accurate angles and surfaces and straight edges.
E. Weld connections to comply with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Weld exposed corners and seams continuously unless otherwise indicated.
   5. At exposed connections, finish exposed welds to comply with NOMMA’s "Voluntary Joint Finish Standards" for Type 1 welds: no evidence of a welded joint.

F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) screws or bolts unless otherwise indicated. Locate joints where least conspicuous.

G. Embed stair nosings into precast concrete treads so that top of abrasive resin insert is less than 1/16 inch above top of tread. Comply with CBC Title 24 Chapter 11B requirements for placement.

H. Finish precast concrete treads as indicated.

2.8 STEEL-FRAMED STAIRS

A. Stair Framing:
   1. Fabricate stringers of steel tubes, plates or channels indicated.
      a. Provide closures for exposed ends of channel tube stringers.
   2. Construct platforms of steel tubes, plates or channels with steel headers and miscellaneous framing members as indicated.
   3. Weld stringers to headers; weld framing members to stringers and headers. [If using bolts, fabricate and join so bolts are not exposed on finished surfaces.]

B. Subtreads, Risers, and Subplatforms:
   1. Fabricate subtreads and subplatforms of steel shapes indicated.
   2. Weld subtreads to stringers. Locate welds on top of subtreads where they will be concealed by finished treads.
   3. Provide subplatforms of configuration indicated or, if not indicated, the same as subtreads. Weld subplatforms to platform framing.
      a. Smooth Soffit Construction: Construct subplatforms with flat metal under surfaces to produce smooth soffits.

2.9 STAIR RAILINGS

A. Comply with applicable requirements in Section 057300 "Decorative Metal Railings."
   1. Connect posts to stair framing by direct welding unless otherwise indicated.

2.10 FINISHES

A. Preparing Nongalvanized Decorative Metal Stairs for Shop Priming:
   1. Prepare uncoated ferrous-metal surfaces to comply with AESS requirements indicated but not less than the following:

2. Prepare concealed uncoated ferrous-metal surfaces to comply with SSPC-SP 3, "Power Tool Cleaning."

B. Primer Application: Apply shop primer to prepared surfaces of railings unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Primer need not be applied to surfaces to be embedded in concrete.

1. Shop prime uncoated metal stairs with rust-inhibitive primers specified in Section 099600 "High-Performance Coatings."


1. Color: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.

B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free of rack.

C. Install metal stairs by welding stair framing to steel structure or to weld plates cast into concrete unless otherwise indicated.

D. Provide temporary bracing or anchors in formwork for items that are to be built into concrete or masonry.

E. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

F. Field Welding: Comply with requirements for welding in "Fabrication, General" Article.

G. Attach precast concrete treads to subtread plates. Adjust levelness for deviation not more than 1/16 inch per 5 feet.
3.2 ADJUSTING AND CLEANING

A. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Section 099600 "High-Performance Coatings."

END OF SECTION
SECTION 057300 - DECORATIVE METAL RAILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Steel railings with stainless-steel cable infill and fittings.
   2. Stainless steel tube handrails and brackets.

B. Related Requirements:
   1. Section 057100 "Decorative Metal Stairs" for ornamental stairs on which to mount decorative railings.
   2. Section 092216 "Non-Structural Metal Framing" for metal backing for anchoring railings.
   3. Section 099600 "High-Performance Coatings" for finish of steel portions of railing system.

1.3 DEFINITIONS

A. Railings: Guards, handrails, and similar devices used for protection of occupants at open-sided floor areas and for pedestrian guidance and support, visual separation, or wall protection.

1.4 COORDINATION AND SCHEDULING

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers’ written instructions to ensure that shop primers and topcoats are compatible.

B. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver items to Project site in time for installation.

C. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not meet structural performance requirements.

1.5 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Manufacturer's product lines of railings, handrails, brackets, cable and fittings assembled from standard components.
   2. Grout, anchoring cement, and paint products.
B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Include plans, elevations, sections, and attachment details.

D. Samples for Initial Selection:
   1. For handrail brackets.
   2. For cable fittings.

E. Samples for Verification: For each type of exposed finish required.
   1. Minimum 12 inch length sections of each distinctly different linear railing member, including handrails, top rails, and posts.
   2. Minimum 12 inch length of cable and each fitting and accessory proposed for the Project. Submit items in specified finish.
   3. Handrail brackets.
   4. Welded connections.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Instructions:
   1. Manufacturer's instructions for periodic checking and adjustment of cables to maintain uniform cable tension.
   2. Manufacturer's recommendation for periodic cleaning to remove accumulated dirt, debris, and stains.

1.7 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
   2. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

B. Provide the following upon request:
   1. Qualification Data: For professional engineer.
   2. Mill Certificates: Signed by manufacturers of stainless-steel products certifying that products furnished comply with requirements.
   3. Welding certificates.
   4. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, according to ASTM E 894 and ASTM E 935.

C. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.
   1. Build mockups as shown on Drawings.
   2. Build mockups for each form and finish of railing consisting of two posts, top rail, cable infill area, and anchorage system components that are full height and are not less than 48 inches in length.
   3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
1.8 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with railings by field measurements before fabrication and indicate measurements on Shop Drawings.

1.9 WARRANTY

A. Special Warranty: Stainless steel cables and connectors against defects in materials and workmanship.
   1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General: In engineering railings to withstand structural loads indicated, allowable design working stresses of railing materials have been based on not less than the following:
   1. Stainless Steel: 60 percent of minimum yield strength.
   2. Steel: 72 percent of minimum yield strength.

B. Structural Performance: Railings, including attachment to building construction, have been designed to withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
   1. Railing frame components and cable hardware designed to withstand loads encountered without excessive deflection or distortion when cables are tensioned to required amounts to conform to building codes.
   2. Cable Railing System, Handrails and Top Rails of Guards:
      a. Uniform load of 50 lb/ft. applied in any direction.
      b. Concentrated load of 200 lb (0.89 kN) applied in any direction.
      c. Uniform and concentrated loads need not be assumed to act concurrently.
   3. Cable Infill:
      a. Concentrated load of 50 lbf applied horizontally on an area of 1 sq. ft. over gross area of cable railing system.
      b. Infill load and other loads need not be assumed to act concurrently.

2.2 MANUFACTURERS

A. Source Limitations: Obtain each type of railing, cables, fittings, and accessories from single source from single manufacturer.
B. Product Options: Information on Drawings and in Specifications establishes requirements for system's aesthetic effects and performance characteristics. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction. Performance characteristics are indicated by criteria subject to verification by one or more methods, including structural analysis, preconstruction testing, field testing, and in-service performance.

1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.

2.3 METALS, GENERAL

A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

B. Brackets, Flanges, and Anchors: Same metal and finish as supported rails unless otherwise indicated.

1. Provide cast-or machined-metal brackets with flange tapped for concealed anchorage to threaded hanger bolt at wall and threaded stud at post as indicated.

C. Handrail Brackets: Final selection by Architect. Subject to compliance with requirements and as approved by Architect, provide Malibu Series Type 316 stainless steel wall-mounted and post-mounted brackets as manufactured by C.R Laurence, Inc., or Architect approved equal.

2.4 STAINLESS STEEL

A. Tubing: ASTM A 554, Grade MT 316.

B. Wire Rope and Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. C. Sherman Johnson, Co., Inc.
   b. Cable Connection (The).
   c. Feeney, Inc.
   d. Hayn Enterprises, LLC.

2. Wire Rope: 3/16 inch diameter minimum, commercial, dry grade; 1-by-19 wire rope made from polished stainless steel wire complying with ASTM A 492, Type 316.
   a. Breaking Strength: Not less than 4700 lbs.

3. Wire-Rope Fittings: Swageless quick connect, concealed threads; ball terminals, ball end turnbuckles, tensioning adjusters, fixed end studs, and other hardware, fabricated from Type 316 tumbled stainless steel, and with capability to sustain, without failure, a load equal to minimum breaking strength of wire rope with which they are used as recommended by manufacturer for installation conditions.

2.5 STEEL AND IRON

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
B. Plates, Shapes, and Bars: ASTM A 36/A 36M, with minimum yield stress of 36 ksi.

2.6 FASTENERS

A. Fastener Materials: Unless otherwise indicated, provide the following:
   1. Stainless-Steel Components: Type 316 stainless-steel fasteners.
   2. Uncoated Steel Components: Type 316 stainless-steel fasteners where exposed.
   3. Dissimilar Metals: Type 316 stainless-steel fasteners.

B. Fasteners for Anchoring to Other Construction: Provide fasteners of type, grade, and class indicated.

C. Provide concealed fasteners for interconnecting railing components and for attaching railings to other work unless exposed fasteners are unavoidable.
   1. Provide tamper-resistant flat-head machine screws for exposed fasteners unless otherwise indicated.

2.7 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

B. Shop Primers: Provide primers that comply with Section 099600 "High-Performance Coatings."

C. Intermediate Coats and Topcoats for Ferrous Metal: Provide products that comply with Section 099600 "High-Performance Coatings."
   2. Polyurethane Topcoat: Compatible with undercoat.

2.8 FABRICATION

A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage.

B. Assemble railings in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

C. Make up wire-rope assemblies in the shop to field-measured dimensions with fittings machine swaged. Minimize amount of turnbuckle take-up used for dimensional adjustment so maximum amount is available for tensioning wire ropes. Tag wire-rope assemblies and fittings to identify installation locations and orientations for coordinated installation.

D. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges. Remove sharp or rough areas on exposed surfaces. Remove weld splatter.
   1. Refer to Section 051213 "Architecturally Exposed Structural Steel (AESS)" for finishing of steel stair components. Provide grading category of Grade AESS 3, or better.

E. Form work true to line and level with accurate angles and surfaces.
F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.

G. Connections: Fabricate railings with welded connections unless otherwise indicated.

H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove flux immediately.
   4. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Type 1 welds; no evidence of a welded joint.

I. Form changes in handrail direction as follows:
   1. By radius bends of radius indicated, or if not indicated, to smallest radius allowable without deformation of metal.

J. Bend members in jigs to produce uniform curvature for each configuration required; maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.

K. Close exposed ends of hollow railing members with prefabricated end fittings.

L. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns, unless clearance between end of rail and wall is 1/4 inch or less.

M. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.
   1. At brackets and fittings fastened to gypsum board partitions, provide crush-resistant fillers, or other means to transfer loads through wall finishes to structural supports and to prevent bracket or fitting rotation and crushing of substrate.

2.9 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipment.

C. Provide exposed fasteners with finish matching appearance, including color and texture, of railings.

2.10 STAINLESS-STEEL FINISHES

A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.

B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
   1. Run grain of directional finishes with long dimension of each piece.

C. Directional Satin Finish: No. 4.
D. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2.11 STEEL AND IRON FINISHES

A. For interior nongalvanized-steel railings, provide nongalvanized ferrous-metal fittings, fasteners, and sleeves, unless otherwise indicated.

B. Preparing Nongalvanized Railings for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with AESS requirements indicated but not less than the following:

C. Primer Application: Apply shop primer to prepared surfaces of railings unless otherwise indicated. Comply with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.
   1. Shop prime uncoated railings with primers specified in Section 099600 "High-Performance Coatings."

   1. Color: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine gypsum board assemblies, where reinforced to receive anchors, to verify that locations of concealed reinforcements have been clearly marked for Installer. Locate reinforcements and mark locations if not already done.

3.2 INSTALLATION, GENERAL

A. Fit exposed connections together to form tight, hairline joints.

B. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.
   1. Do not weld, cut, or abrade surfaces of railing components that have been coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
   2. Set posts plumb within a tolerance of 1/16 inch in 3 feet.
   3. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet.

C. Adjust railings before anchoring to ensure matching alignment at abutting joints.
D. Fastening to In-Place Construction: Use anchorage devices and fasteners indicated.

3.3 RAILING CONNECTIONS

A. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.

B. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches of post.

3.4 ANCHORING POSTS

A. Weld posts to metal stair framing as indicated. Refer to Section 051213 "Architecturally Exposed Structural Steel (AESS)" for finishing of steel stair components for Grade indicated.

3.5 CABLE RAILING

A. Install cable railing system in accordance with manufacturer's instructions at locations indicated on the drawings.

B. Install cable railing system plumb, level, square, and rigid.

C. Anchor cable railing system to mounting surface as indicated on the drawings.

D. Use manufacturer's supplied cable hardware.

E. Terminate and tension cables in accordance with manufacturer's instructions.
   1. Tension cables to a minimum of 225 pounds each in sequence in accordance with manufacturer's instructions.

F. Ensure cables are clean, parallel to each other, and without kinks or sags.

G. Replace defective or damaged components as directed by Architect.

H. Repair damaged factory-applied finish as directed by Architect.

3.6 ATTACHING RAILINGS

A. Attach handrails to railing posts with post brackets and to walls with wall brackets. Provide brackets with 1-1/2-inch clearance from inside face of handrail and finished wall surface. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
   1. Walls: Use type of bracket with flange tapped for concealed anchorage to threaded hanger bolt.
   2. Posts: Use type of bracket with flange tapped for concealed anchorage to tapped steel solid bar post as indicated.
   3. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
B. Secure wall brackets to building construction as follows:
   1. For steel-framed partitions, fasten brackets with fasteners as indicated in Drawings installed through flanges of steel framing or through concealed steel reinforcements.

3.7 CLEANING
   
A. Clean stainless steel by washing thoroughly with clean water and soap, rinsing with clean water, and wiping dry.

B. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
   1. Apply by brush or spray to provide a minimum 2.0-mil dry film thickness.

3.8 PROTECTION
   
A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.

B. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION
SECTION 060413 - COMMON SUBMITTAL REQUIREMENTS FOR WOODS, PLASTICS, AND COMPOSITES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:

1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.

1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:

1. Shop Drawings.
2. Product Data.
3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect’s staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect’s notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.

1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.

1. Submittal Numbering: See below.
2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition

1. Each submittal consists of items from only ONE Specifications section.
2. **Complete Submittal:** If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. **Partial Submittals:** If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. **All items in each submittal, whether complete or partial, will be processed together:** Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

**C. Submittal Numbering**

1. Number submittals as described below to assist tracking.

2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. **P-Number for Partial Submittals:** Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. **R-Number for Re-submittals:** Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. **Examples:**

**3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS**

**A.** Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

**B.** When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

**C.** Do not edit any of the information contained within the Submittal Review Sheet except as follows:

1. **Submittal Number:** See Submittal Numbering in Submittal Transmittal Requirements paragraph.

**D.** The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Wood blocking and nailers.
   2. Wood furring.
   4. Plywood backing panels.

B. Related Requirements:
   1. Section 061600 "Sheathing."

1.3 DEFINITIONS

A. Lumber grading agencies, and the abbreviations used to reference them, include the following:
   1. NLGA: National Lumber Grades Authority.
   2. WCLIB: West Coast Lumber Inspection Bureau.
   3. WWPA: Western Wood Products Association.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
   1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.
   2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
   3. For fire-retardant treatments, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency according to ASTM D 5664.
   4. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.
   5. Include copies of warranties from chemical treatment manufacturers for each type of treatment.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Fastener Patterns: Full-size templates for fasteners in exposed framing.
1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer that is certified for chain of custody by an FSC-accredited certification body.

B. Vendor Qualifications: A vendor that is certified for chain of custody by an FSC-accredited certification body.

C. Provide the following upon request:
   1. Material Certificates: For dimension lumber specified to comply with minimum allowable unit stresses. Indicate species and grade selected for each use and design values approved by the ALSC Board of Review.
   2. Evaluation Reports: For the following, from ICC-ES:
      a. Wood-preservative-treated wood.
      b. Fire-retardant-treated wood.
      c. Power-driven fasteners.
      d. Powder-actuated fasteners.
      e. Expansion anchors.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Stack lumber flat with spacers beneath and between each bundle to provide air circulation. Protect lumber from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS, GENERAL

A. Lumber: DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Provide lumber graded by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.
   1. Factory mark each piece of lumber with grade stamp of grading agency.

B. Maximum Moisture Content of Lumber: 19 percent unless otherwise indicated.

2.2 WOOD-PRESERVATIVE-TREATED LUMBER

A. Preservative Treatment by Pressure Process: AWPA U1; Use Category UC2 for interior construction not in contact with the ground, Use Category UC3b for exterior construction not in contact with the ground, and Use Category UC4a for items in contact with the ground.
   1. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium. Do not use inorganic boron (SBX) for sill plates.

B. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Do not use material that is warped or that does not comply with requirements for untreated material.
C. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.

D. Application: Treat items indicated on Drawings, and the following:
   1. Wood sills, sleepers, blocking, and similar concealed members in contact with masonry or concrete.
   2. Wood framing and furring attached directly to the interior of below-grade exterior masonry or concrete walls.
   3. Wood framing members that are less than 18 inches above the ground in crawlspaces or unexcavated areas.

2.3 FIRE-RETARDANT-TREATED MATERIALS

A. General: Where fire-retardant-treated materials are indicated, use materials complying with requirements in this article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.

B. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Products with a flame spread index of 25 or less when tested according to ASTM E 84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet beyond the centerline of the burners at any time during the test.
   1. Use treatment that does not promote corrosion of metal fasteners.
   2. Exterior Type: Treated materials shall comply with requirements specified above for fire-retardant-treated lumber and plywood by pressure process after being subjected to accelerated weathering according to ASTM D 2898. Use for exterior locations and where indicated.
   3. Interior Type A: Treated materials shall have a moisture content of 28 percent or less when tested according to ASTM D 3201 at 92 percent relative humidity. Use where exterior type is not indicated.
   4. Design Value Adjustment Factors: Treated lumber shall be tested according ASTM D 5664 and design value adjustment factors shall be calculated according to ASTM D 6841. For enclosed roof framing, framing in attic spaces, and where high temperature fire-retardant treatment is indicated, provide material with adjustment factors of not less than 0.85 modulus of elasticity and 0.75 for extreme fiber in bending for Project's climatological zone.

C. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent.[ Kiln-dry plywood after treatment to a maximum moisture content of 15 percent.]

D. Identify fire-retardant-treated wood with appropriate classification marking of qualified testing agency.

E. Application: Treat items indicated on Drawings, and the following:
   1. Roof-related construction.
   2. Plywood backing panels.

2.4 MISCELLANEOUS LUMBER

A. General: Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:
1. Blocking.
2. Nailers.
3. Furring.

B. For items of dimension lumber size, provide Construction or No. 2 grade lumber and any of the following species:
   1. Hem-fir; WCLIB or WWPA.
   2. Spruce-pine-fir (south); WCLIB, or WWPA.
   3. Western woods; WCLIB or WWPA.

C. For concealed boards, provide lumber with 15 percent maximum moisture content and any of the following species and grades:
   1. Hem-fir or hem-fir (north); Construction or No. 2 Common grade; NLGA, WCLIB, or WWPA.
   2. Spruce-pine-fir (south) or spruce-pine-fir; Construction or No. 2 Common grade; NLGA, WCLIB, or WWPA.
   3. Western woods; Construction or No. 2 Common grade; WCLIB or WWPA.

D. For blocking not used for attachment of other construction, Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.

E. For blocking and nailers used for attachment of other construction, select and cut lumber to eliminate knots and other defects that will interfere with attachment of other work.

F. For furring strips for installing plywood or hardboard paneling, select boards with no knots capable of producing bent-over nails and damage to paneling.

2.5 SHELVING AND CLOTHES RODS

A. Utility Shelving: Made from the following material, 3/4 inch thick.
   1. Melamine-faced particleboard with applied-PVC front edge.

B. Shelf Cleats: 3/4-by-5-1/2-inch boards with hole and notch to receive clothes rods, as specified above for shelving.

C. Shelf Brackets with Rod Support: BHMA A156.16, B04051; prime-painted formed steel.

D. Shelf Brackets without Rod Support: BHMA A156.16, B04041; prime-painted formed steel.

E. Standards for Adjustable Shelf Brackets: BHMA A156.9, B04102; powder-coat-finished steel.

F. Adjustable Shelf Brackets: BHMA A156.9, B04112; powder-coat-finished steel.


H. Rod Flanges: Aluminum.

2.6 PLYWOOD BACKING PANELS

A. Equipment Backing Panels: DOC PS 1, Exterior, C-C Plugged, fire-retardant treated, in thickness indicated or, if not indicated, not less than 3/4-inch nominal thickness; painted.
2.7 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.
   1. Where rough carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners of Type 304 stainless steel.

B. Nails, Brads, and Staples: ASTM F 1667.


D. Wood Screws: ASME B18.6.1.

E. Lag Bolts: ASME B18.2.1.

F. Bolts: Steel bolts complying with ASTM A 307, Grade A; with ASTM A 563 hex nuts and, where indicated, flat washers.

G. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated.
   1. Material: Stainless steel with bolts and nuts complying with ASTM F 593 and ASTM F 594, Alloy Group 1 or 2.

2.8 MISCELLANEOUS MATERIALS

A. Flexible Flashing: Composite, self-adhesive, flashing product consisting of a pliable, rubberized-asphalt compound, bonded to a high-density polyethylene film, aluminum foil, or spunbonded polyolefin to produce an overall thickness of not less than 0.025 inch.

B. Water-Repellent Preservative: NWWDA-tested and -accepted formulation containing 3-iodo-2-propynyl butyl carbamate, combined with an insecticide containing chloropyrifos as its active ingredient.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Set rough carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry to other construction; scribe and cope as needed for accurate fit. Locate furring, nailers, blocking, and similar supports to comply with requirements for attaching other construction.

B. Install plywood backing panels by fastening to studs; coordinate locations with utilities requiring backing panels. Install fire-retardant treated plywood backing panels with classification marking of testing agency exposed to view.

C. Do not splice structural members between supports unless otherwise indicated.

D. Provide blocking and framing as indicated and as required to support facing materials, fixtures, specialty items, and trim.
1. Provide metal clips for fastening gypsum board or lath at corners and intersections where framing or blocking does not provide a surface for fastening edges of panels. Space clips not more than 16 inches o.c.

E. Sort and select lumber so that natural characteristics will not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.

F. Comply with AWPA M4 for applying field treatment to cut surfaces of preservative-treated lumber.
   1. Use inorganic boron for items that are continuously protected from liquid water.
   2. Use copper naphthenate for items not continuously protected from liquid water.

G. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
   1. NES NER-272 for power-driven fasteners; or.

H. Use steel common nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood. Drive nails snug but do not countersink nail heads unless otherwise indicated.

I. For exposed work, arrange fasteners in straight rows parallel with edges of members, with fasteners evenly spaced, and with adjacent rows staggered.
   1. Comply with approved fastener patterns where applicable. Before fastening, mark fastener locations, using a template made of sheet metal, plastic, or cardboard.
   2. Use finishing nails unless otherwise indicated. Countersink nail heads and fill holes with wood filler.

3.2 WOOD BLOCKING, AND NAILER INSTALLATION

A. Install where indicated and where required for attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.

B. Attach items to substrates to support applied loading. Recess bolts and nuts flush with surfaces unless otherwise indicated.

C. Where wood-preservative-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.

3.3 WOOD FURRING INSTALLATION

A. Install level and plumb with closure strips at edges and openings. Shim with wood as required for tolerance of finish work.

B. Furring to Receive Plywood or Hardboard Paneling: Install 1-by-3-inch nominal- size furring horizontally at 24 inches o.c.
3.4 PROTECTION

A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

B. Protect rough carpentry from weather. If, despite protection, rough carpentry becomes sufficiently wet that moisture content exceeds that specified, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION
SECTION 061600 - SHEATHING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Exterior glass-mat wall sheathing.
   2. Exterior cement board wall sheathing.
   3. Laminated structural shear wall panels

B. Related Requirements:
   1. Section 061000 "Rough Carpentry" for plywood backing panels.
   2. Section 072100 "Thermal Insulation" for thermal spacers and furring for installation of cement backer boards over continuous insulation.
   3. Section 072726 "Membrane Air Barriers" for water-resistive barrier applied over wall sheathing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For laminated structural shear wall panels as follows:
   1. Shear wall layout, framing and supports, with dimensions and sections.
   2. Shear wall/Diaphragm load tables using specified shear wall panels, fastener size/type and spacing shall be attached to designed shear walls that define the size of required collector posts for shear, along with required wall framing hardware, size or gage and on center stud/joist spacing for Vertical/Diaphragm and Concentrated loads as well as lateral load resistance that have been engineered.
   3. Details of proprietary or non-proprietary components if included.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: For testing agency providing classification marking for fire-retardant-treated material, an inspection agency acceptable to authorities having jurisdiction that periodically performs inspections to verify that the material bearing the classification marking is representative of the material tested.
1.5 DELIVERY, STORAGE, AND HANDLING

A. Package and handle sheathing to prevent damage during shipping and unloading.

B. Stack panels flat off of ground with spacers beneath and between each bundle to provide air circulation. Protect sheathing from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: For assemblies with fire-resistance ratings, provide materials and construction identical to those of assemblies tested for fire resistance per ASTM E 119 by a testing and inspecting agency acceptable to authorities having jurisdiction.


2.2 EXTERIOR WALL SHEATHING

A. Drawing Keynote Type: "Exterior Sheathing"

   a. Basis-of-Design Product: Subject to compliance with requirements, provide Dens-Glass Gold as manufactured by G-P Gypsum Corporation, or comparable by one of the following tested components in NFPA 285 compliant assembly:
      1) CertainTeed Corporation; GlasRoc.
      2) National Gypsum Company; Gold Bond e(2)XP.
      3) United States Gypsum Co.;

2. Type and Thickness: Type X, 5/8 inch thick.

B. Drawing Keynote Type: "Exterior Sheathing Type-2"

   a. Basis-of-Design Product: Subject to compliance with requirements, provide Dens-Deck Prime as manufactured by G-P Gypsum Corporation, or comparable by one of the following:
      1) CertainTeed Corporation;
      2) National Gypsum Company.
      3) United States Gypsum Co.;

2. Type and Thickness: Type X, 5/8 inch thick.

2.3 CEMENT BOARD WALL SHEATHING

A. Cementitious Backer Units: ASTM C 1325, Type A.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. C-Cure; C-Cure Board 990.
b. Custom Building Products; Wonderboard.
c. FinPan, Inc.; Util-A-Crete Concrete Backer Board.
d. USG Corporation; DUROCK Cement Board.

2. Thickness: 5/8 inch, except use 1/2 inch at ceiling/soffits.

2.4 PARAPET SHEATHING

A. Glass-Mat Faced Gypsum Roof Board: ASTM C 1177.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide DensDeck Roof Board as manufactured by G-P Gypsum Corporation, or comparable by one of the following:
      a. CertainTeed Corporation.
      c. United States Gypsum Co.
   2. Thickness: 5/8 inch thick.

2.5 LAMINATED STRUCTURAL SHEAR WALL PANELS

A. Shear Wall Shear Capacity:
   1. Refer to Drawings and Section 054000 "Cold-Formed Metal Framing" for gage for framing and attachment of the laminated structural shear wall panels to provide a panel shear capacity in accordance with IAPMO-ES evaluation report number ER-0126/ICC-ES evaluation Report ER 5762 as applicable.
   2. No other similar materials, stated load capacities or methods of attachment to framing studs/track/plates other than those stated on these approvals for Sure-Board® products will be acceptable as an equal.
   3. Changes to the specified products are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

B. Drawing Keynote Type: "Exterior Sheathing Type-3":
   1. Description: Galvanized steel sheet laminated to glass-mat-faced gypsum panels, as follows:
      a. Steel sheet: 0.027-inch thick (22-gauge) minimum ASTM A 653 CS, Grade 33, with G-40 hot-dipped galvanized coating conforming to ASTM A924.
      b. Adhesive; Water soluble
      c. Panel: Glass-mat-faced gypsum sheathing, ASTM C 1177, 5/8-inch thick, Type 'X'.
      d. Fasteners: Self-drilling, self-tapping pilot point bugle head screws, #8 by 1-5/8-inch, unless otherwise indicated, with cutting nubs under screw head to seat into sheathing. Fasteners shall be provided by sheathing manufacturer.
      e. Product: Sure-Board Series 200 Structural Sheathing Panels as manufactured by CEMCO.

C. Drawing Keynote Type: "Interior Sheathing Type-1"
   1. Description: Galvanized steel sheet laminated to gypsum board panels, as follows:
      a. Steel sheet: 0.027-inch thick (22-gauge) minimum ASTM A 653 CS, Grade 33, with G-40 hot-dipped galvanized coating conforming to ASTM A924.
      b. Adhesive; Water soluble
      c. Panel: Gypsum Board, ASTM C 1369, 5/8-inch thick, Type 'X'.
d. Fasteners: Self-drilling, self-tapping pilot point bugle head screws, #8 by 1-5/8-inch, unless otherwise indicated, with cutting nubs under screw head to seat into sheathing. Fasteners shall be provided by sheathing manufacturer.

e. Finish: Level 5, in accordance with Section 092900 "Gypsum Board."

f. Product: Sure-Board Series 200 Structural Sheathing Panels as manufactured by CEMCO.

2.6 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.

1. For wall sheathing, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M.

B. Nails, Brads, and Staples: ASTM F 1667.


D. Screws for Fastening Gypsum Sheathing to Cold-Formed Metal Framing: Steel drill screws, in length recommended by sheathing manufacturer for thickness of sheathing to be attached, with organic-polymer or other corrosion-protective coating having a salt-spray resistance of more than 800 hours according to ASTM B 117.

1. For steel framing less than 0.0329 inch thick, use screws that comply with ASTM C 1002.
2. For steel framing from 0.033 to 0.112 inch thick, use screws that comply with ASTM C 954.

E. For structural shear wall panels, use fasteners indicated as minimum or as required by manufacturer for imposed loads.

2.7 SHEATHING JOINT-AND-PENETRATION TREATMENT MATERIALS

A. Sealant for Glass-Mat Gypsum Sheathing: Silicone emulsion sealant complying with ASTM C 834, compatible with sheathing tape and sheathing and recommended by tape and sheathing manufacturers for use with glass-fiber sheathing tape and for covering exposed fasteners.

1. Sheathing Tape: Self-adhering glass-fiber tape, minimum 2 inches wide, 10 by 10 or 10 by 20 threads/inch, of type recommended by sheathing and tape manufacturers for use with silicone emulsion sealant in sealing joints in glass-mat gypsum sheathing and with a history of successful in-service use.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement. Arrange joints so that pieces do not span between fewer than three support members.

B. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction unless otherwise indicated.
C. Securely attach to substrate by fastening as indicated, complying with the following:
   1. NES NER-272 for power-driven fasteners.
   2. Table 2304.9.1, "Fastening Schedule," in ICC's "International Building Code."

D. Use common wire nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections. Install fasteners without splitting wood.

E. Coordinate wall sheathing installation with flashing and joint-sealant installation so these materials are installed in sequence and manner that prevent exterior moisture from passing through completed assembly.

F. Do not bridge building expansion joints; cut and space edges of panels to match spacing of structural support elements.

G. Coordinate sheathing installation with installation of materials installed over sheathing so sheathing is not exposed to precipitation or left exposed at end of the workday when rain is forecast.

3.2 GYPSUM SHEATHING INSTALLATION

A. Comply with GA-253 and with manufacturer's written instructions.
   1. Fasten gypsum sheathing to cold-formed metal framing with screws.
   2. Install boards with a 3/8-inch gap where non-load-bearing construction abuts structural elements.
   3. Install boards with a 1/4-inch gap where they abut masonry or similar materials that might retain moisture, to prevent wicking.

B. Apply fasteners so heads bear tightly against face of sheathing, but do not cut into facing.

C. Horizontal Installation: Install sheathing with V-grooved edge down and tongue edge up. Interlock tongue with groove to bring long edges in contact with edges of adjacent boards without forcing. Abut ends of boards over centers of studs, and stagger end joints of adjacent boards not less than one stud spacing. Attach boards at perimeter and within field of board to each steel stud.
   1. Space fasteners approximately 8 inches o.c. and set back a minimum of 3/8 inch from edges and ends of boards.
   2. For sheathing under stucco cladding, boards may be initially tacked in place with screws if overlying self-furring metal lath is screw-attached through sheathing to studs immediately after sheathing is installed.

D. Vertical Installation: Install board vertical edges centered over studs. Abut ends and edges of each board with those of adjacent boards. Attach boards at perimeter and within field of board to each stud.
   1. Space fasteners approximately 8 inches o.c. and set back a minimum of 3/8 inch from edges and ends of boards.
   2. For sheathing under stucco cladding, boards may be initially tacked in place with screws if overlying self-furring metal lath is screw-attached through sheathing to studs immediately after sheathing is installed.

E. Seal sheathing joints according to sheathing manufacturer's written instructions.
1. Apply elastomeric sealant to joints and fasteners and trowel flat. Apply sufficient amount of sealant to completely cover joints and fasteners after troweling. Seal other penetrations and openings.

2. Apply glass-fiber sheathing tape to glass-mat gypsum sheathing joints and apply and trowel silicone emulsion sealant to embed entire face of tape in sealant. Apply sealant to exposed fasteners with a trowel so fasteners are completely covered. Seal other penetrations and openings.

3.3 CEMENTITIOUS BACKER UNIT INSTALLATION

A. Install panels and treat joints according to ANSI A108.11 and manufacturer's written instructions for type of application indicated.

B. Cementitious Backer Units: Install over thermal spacers and furring. Refer to Section 07 2100 "Thermal Insulation" for products and installation requirements of thermal spacers and furring.

3.4 LAMINATED STRUCTURAL PANEL INSTALLATION

A. Comply with ASTM C 846 and with manufacturer's written instructions.

B. Install sheathing vertically with long edges parallel to, and centered over, studs. Install solid wood blocking where end joints do not occur over framing. Allow 1/8-inch open space between edges and ends of adjacent units. Stagger horizontal joints if any. Install and fasten according to sheathing manufacturer's written instructions in accordance with performance requirements.

C. Fastening Methods: Fasten panels in accordance with manufacturer's instructions and in accordance with structural design as indicated below:

1. Wall and Roof Sheathing:
   a. Screw to cold-formed metal framing. Avoid jacking of sheet steel from the stud and track during installation.
   b. Space panels 1/8 inch apart at edges and ends.
   c. Provide screws on edges and field in accordance with Structural Drawings.

D. Finishing: Tape and seal exterior glass-mat-faced gypsum panels according to gypsum panel manufacturer's written instructions and as indicated above. Finish interior gypsum board panels in accordance with finish indicated.

END OF SECTION
SECTION 064116 - PLASTIC-LAMINATE-FACED ARCHITECTURAL CABINETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section Includes:
      1. Plastic-laminate-faced architectural cabinets.
      2. Wood furring, blocking, shims, and hanging strips for installing plastic-laminate-faced architectural cabinets unless concealed within other construction before cabinet installation.
   B. Related Requirements:
      1. Section 061000 "Rough Carpentry" for wood furring, blocking, shims, and hanging strips required for installing cabinets and concealed within other construction before cabinet installation.

1.3 PREINSTALLATION MEETINGS
   A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product - panel products, high-pressure decorative laminate, adhesive for bonding plastic laminate, fire-retardant-treated materials, and cabinet hardware and accessories.
      1. Include data for fire-retardant treatment from chemical-treatment manufacturer and certification by treating plant that treated materials comply with requirements.
   B. Sustainable Design Submittals required by Section 01813 applicable to this Section.
   C. Shop Drawings: Show location of each item, dimensioned plans and elevations, large-scale details, attachment devices, and other components.
      1. Show details full size.
      2. Show locations and sizes of furring, blocking, and hanging strips, including concealed blocking and reinforcement specified in other Sections.
      3. Show locations and sizes of cutouts and holes for [electrical switches and outlets] [and other items] installed in architectural plastic-laminate cabinets.
   D. Samples for Initial Selection:
      1. PVC edge material.
      2. Thermoset decorative panels.
E. Samples for Verification:
   1. Plastic laminates, 8 by 10 inches, for each color, pattern, and surface finish, with one sample applied to core material and specified edge material applied to one edge.
   2. Thermoset decorative panels, 8 by 10 inches, for each color, pattern, and surface finish, with edge banding on one edge.
   3. Exposed cabinet hardware and accessories, one unit for each type and finish.

1.5 QUALITY ASSURANCE

A. Fabricator Qualifications: Shop that employs skilled workers who custom fabricate products similar to those required for this Project and whose products have a record of successful in-service performance. Shop is a certified participant in AWI's Quality Certification Program or is a licensee of WI's Certified Compliance Program.

B. Installer Qualifications: Fabricator of products.

C. Provide the following upon request:
   1. Qualification Data: For fabricator.
   2. Product Certificates: For the following:
      a. Composite wood and agrifiber products.
      b. Thermoset decorative panels.
      c. High-pressure decorative laminate.
      d. Adhesives.
   3. Evaluation Reports: For fire-retardant-treated materials, from ICC-ES.

D. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Build mockups of typical plastic-laminate cabinets as shown on Drawings.
   2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not deliver cabinets until painting and similar operations that could damage woodwork have been completed in installation areas. If cabinets must be stored in other than installation areas, store only in areas where environmental conditions comply with requirements specified in "Field Conditions" Article.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Do not deliver or install cabinets until building is enclosed, wet work is complete, and HVAC system is operating and maintaining temperature between 60 and 90 deg F and relative humidity between 43 and 70 percent during the remainder of the construction period.

B. Field Measurements: Where cabinets are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication, and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
PLASTIC-LAMINATE-FACED ARCHITECTURAL CABINETS

A. Quality Standard: Unless otherwise indicated, comply with the "Architectural Woodwork Standards" for grades of architectural plastic-laminate cabinets indicated for construction, finishes, installation, and other requirements.
1. The Contract Documents contain selections chosen from options in the quality standard and additional requirements beyond those of the quality standard. Comply with those selections and requirements in addition to the quality standard.

B. Grade: Custom.

C. Regional Materials: Wood products shall be manufactured within 100 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

D. Certified Wood: Plastic-laminate cabinets shall be made from wood products certified as "FSC Pure" or "FSC Mixed Credit" according to FSC STD-01-001 and FSC STD-40-004.

E. Type of Construction: Frameless.

F. Cabinet, Door, and Drawer Front Interface Style: Flush overlay.

G. High-Pressure Decorative Laminate: NEMA LD 3, grades as indicated or if not indicated, as required by woodwork quality standard.
1. Manufacturers: Subject to compliance with requirements, provide products indicated on Drawings, or comparable by one of the following:
   a. Abet Laminati, Inc.
   b. Formica Corporation.
c. Lamin-Art, Inc.
d. Panolam Industries International, Inc.
e. Wilsonart International; Div. of Premark International, Inc.

H. Laminate Cladding for Exposed Surfaces:
1. Horizontal Surfaces: Grade HGS.
2. Vertical Surfaces: Grade HGS.
3. Edges: Grade HGS PVC edge banding, 0.12 inch thick, matching laminate in color, pattern, and finish.
4. Pattern Direction: Vertically for doors and fixed panels, horizontally for drawer fronts.

I. Materials for Semiexposed Surfaces:
1. Surfaces Other Than Drawer Bodies: Thermoset decorative panels.
   a. Edges of Plastic-Laminate Shelves: PVC edge banding, 0.12 inch thick, matching laminate in color, pattern, and finish.
   b. Edges of Thermoset Decorative Panel Shelves: PVC or polyester edge banding.
   c. For semiexposed backs of panels with exposed plastic-laminate surfaces, provide surface of high-pressure decorative laminate, NEMA LD 3, Grade VGS.
2. Drawer Sides and Backs: Thermoset decorative panels with PVC or polyester edge banding.
3. Drawer Bottoms: Thermoset decorative panels.

J. Dust Panels: 1/4-inch plywood or tempered hardboard above compartments and drawers unless located directly under tops.

K. Concealed Backs of Panels with Exposed Plastic-Laminate Surfaces: High-pressure decorative laminate, NEMA LD 3, Grade BKL.

L. Drawer Construction: Fabricate with exposed fronts fastened to subfront with mounting screws from interior of body.
   1. Join subfronts, backs, and sides with glued rabbeted joints supplemented by mechanical fasteners.

M. Colors, Patterns, and Finishes: Provide materials and products that result in colors and textures of exposed laminate surfaces complying with the following requirements:
   1. As indicated by laminate manufacturer's designations.

2.3 WOOD MATERIALS

A. Wood Products: Provide materials that comply with requirements of referenced quality standard for each type of woodwork and quality grade specified unless otherwise indicated.
   1. Wood Moisture Content: 8 to 13 percent.

B. Composite Wood and Agrifiber Products: Provide materials that comply with requirements of referenced quality standard for each type of woodwork and quality grade specified unless otherwise indicated.
   1. Recycled Content of MDF and Particleboard: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
2. Composite Wood Products: Products shall be made using ultra-low-emitting
formaldehyde resins as defined in the California Air Resources Board's "Airborne Toxic
Control Measure to Reduce Formaldehyde Emissions from Composite Wood Products"
or shall be made with no added formaldehyde.

3. MDF: ANSI A208.2, Grade 130.

4. Straw Based Particleboard: ANSI A208.1, Grade M-2, except for density.
   a. Products: Subject to compliance with requirements, [provide the following]
      [provide one of the following] [available products that may be incorporated into the
      Work include, but are not limited to, the following]:
      1) Environ Biocomposites Manufacturing LLC; Biofiber Wheat.
      2) Sorm Incorporated; Primeboard Premium Wheat.

5. Softwood Plywood: DOC PS 1, medium-density overlay.

6. Thermoset Decorative Panels: Particleboard or medium-density fiberboard finished with
   thermally fused, melamine-impregnated decorative paper and complying with
   requirements of NEMA LD 3, Grade VGL, for test methods 3.3, 3.4, 3.6, 3.8, and 3.10.

2.4 FIRE-RETARDANT-TREATED MATERIALS

A. Fire-Retardant-Treated Materials, General: Where fire-retardant-treated materials are
   indicated, use materials complying with requirements in this article that are acceptable to
   authorities having jurisdiction and with fire-test-response characteristics specified as determined
   by testing identical products per test method indicated by a qualified testing agency.
   1. Use treated materials that comply with requirements of referenced woodworking
      standard. Do not use materials that are warped, discolored, or otherwise defective.
   2. Use fire-retardant-treatment formulations that do not bleed through or otherwise
      adversely affect finishes. Do not use colorants to distinguish treated materials from
      untreated materials.
   3. Identify fire-retardant-treated materials with appropriate classification marking of qualified
      testing agency in the form of removable paper label or imprint on surfaces that will be
      concealed from view after installation.

B. Fire-Retardant-Treated Lumber and Plywood: Products with a flame-spread index of 25 or less
   when tested according to ASTM E 84, with no evidence of significant progressive combustion
   when the test is extended an additional 20 minutes, and with the flame front not extending more
   than 10.5 feet beyond the centerline of the burners at any time during the test.
   1. Kiln dry lumber and plywood after treatment to a maximum moisture content of 19 and 15
      percent, respectively.
   2. For items indicated to receive a stained or natural finish, use organic resin chemical
      formulation.

C. Fire-Retardant Fiberboard: Medium-density fiberboard panels complying with ANSI A208.2,
   made from softwood fibers, synthetic resins, and fire-retardant chemicals mixed together at time
   of panel manufacture to achieve flame-spread index of 25 or less and smoke-developed index
   of 200 or less per ASTM E 84.
   1. Products: Subject to compliance with requirements, available products that may be
      incorporated into the Work include, but are not limited to, the following:
      b. SierraPine; Medite FR.
2.5 CABINET HARDWARE AND ACCESSORIES

A. Frameless Concealed Hinges (European Type): BHMA A156.9, B01602, 170 degrees of opening, self-closing.

B. Wire Pulls: Back mounted, solid metal, 4 inches long, 5/16 inch in diameter.

C. Catches: Push-in magnetic catches, BHMA A156.9, B03131.

D. Adjustable Shelf Standards and Supports: BHMA A156.9, B04071; with shelf rests, B04081.

E. Shelf Rests: BHMA A156.9, B04013; metal, two-pin type with shelf hold-down clip.

F. Drawer Slides: BHMA A156.9.
   1. Grade 1 and Grade 2: Side mounted[ and extending under bottom edge of drawer]; partial-extension type; epoxy-coated steel with polymer rollers.
   2. Grade 1HD-100 and Grade 1HD-200: Side mounted; full-overtravel-extension type; zinc-plated-steel ball-bearing slides.
   3. For drawers not more than 3 inches high and not more than 24 inches wide, provide Grade 1.
   4. For drawers more than 3 inches high but not more than 6 inches high and not more than 24 inches wide, provide Grade 1HD-100.
   5. For drawers more than 6 inches high or more than 24 inches wide, provide Grade 1HD-200.
   6. For computer keyboard shelves, provide Grade 1.

G. Door Locks: BHMA A156.11, E07121.

H. Drawer Locks: BHMA A156.11, E07041.

I. Door and Drawer Silencers: BHMA A156.16, L03011.

J. Exposed Hardware Finishes: For exposed hardware, provide finish that complies with BHMA A156.18 for BHMA finish number indicated.
   1. Satin Stainless Steel: BHMA 630.

K. For concealed hardware, provide manufacturer's standard finish that complies with product class requirements in BHMA A156.9.

2.6 MISCELLANEOUS MATERIALS

A. Furring, Blocking, Shims, and Hanging Strips: [Softwood or hardwood lumber] [Fire-retardant-treated softwood lumber], kiln dried to less than 15 percent moisture content.

B. Anchors: Select material, type, size, and finish required for each substrate for secure anchorage. Provide metal expansion sleeves or expansion bolts for post-installed anchors. Use nonferrous-metal or hot-dip galvanized anchors and inserts at inside face of exterior walls and at floors.

C. Adhesives: Use adhesives that meet the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

D. Adhesive for Bonding Plastic Laminate: Unpigmented contact cement.
1. Adhesive for Bonding Edges: Hot-melt adhesive or adhesive specified above for faces.

2.7 FABRICATION

A. Sand fire-retardant-treated wood lightly to remove raised grain on exposed surfaces before fabrication.

B. Fabricate cabinets to dimensions, profiles, and details indicated.

C. Complete fabrication, including assembly and hardware application, to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

D. Shop-cut openings to maximum extent possible to receive hardware, appliances, electrical work, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.

E. Cabinet Doors:
   1. Doors Up To 80 Inches High: 3/4 inch thick panel product.
   2. Doors Over 80 Inches High: 1-3/8" thick solid-core, custom grade, 3 or 5 ply, particleboard core with stiles and rails bonded to core, WDMA I.S.1-A standard duty. Face finish same as custom cabinets. Comply with AWI Section 9.

PART 3 - EXECUTION

3.1 PREPARATION

A. Before installation, condition cabinets to average prevailing humidity conditions in installation areas.

B. Before installing cabinets, examine shop-fabricated work for completion and complete work as required.

3.2 INSTALLATION

A. Grade: Install cabinets to comply with same grade as item to be installed.

B. Assemble cabinets and complete fabrication at Project site to the extent that it was not completed in the shop.

C. Install cabinets level, plumb, true, and straight. Shim as required with concealed shims. Install level and plumb to a tolerance of 1/8 inch in 96 inches.

D. Scribe and cut cabinets to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.
E. Anchor cabinets to anchors or blocking built in or directly attached to substrates. Secure with countersunk, concealed fasteners and blind nailing. Use fine finishing nails or finishing screws for exposed fastening, countersunk and filled flush with woodwork.

1. Use filler matching finish of items being installed.

F. Cabinets: Install without distortion so doors and drawers fit openings properly and are accurately aligned. Adjust hardware to center doors and drawers in openings and to provide unencumbered operation. Complete installation of hardware and accessory items as indicated.

1. Install cabinets with no more than 1/8 inch in 96-inch sag, bow, or other variation from a straight line.
2. Fasten wall cabinets through back, near top and bottom, and at ends not more than 16 inches o.c. with toggle bolts through metal backing or metal framing behind wall finish.

3.3 ADJUSTING AND CLEANING

A. Repair damaged and defective cabinets, where possible, to eliminate functional and visual defects; where not possible to repair, replace woodwork. Adjust joinery for uniform appearance.

B. Clean, lubricate, and adjust hardware.

C. Clean cabinets on exposed and semiexposed surfaces.

END OF SECTION
SECTION 066400 - PLASTIC PANELING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Plastic sheet paneling.

B. Related Requirements:
   1. Section 061000 "Rough Carpentry" for wood furring for installing plastic paneling.
   2. Section 102600 "Wall and Door Protection" for impact-resistant plastic paneling used as wall protection.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Samples: For plastic paneling and trim accessories, in manufacturer's standard sizes.

1.4 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install plastic paneling until spaces are enclosed and weathertight and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain plastic paneling and trim accessories from single manufacturer.

2.2 PLASTIC SHEET PANELING

A. Glass-Fiber-Reinforced Plastic Paneling, Type FRP: Gelcoat-finished, glass-fiber-reinforced plastic panels complying with ASTM D 5319. Panels shall be USDA accepted for incidental food contact.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Crane Composites, Inc.
   b. Glasteel.
   c. Marlite.
   d. Newcourt, Inc.
   e. Nudo Products, Inc.

2. Wall materials shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

3. Surface-Burning Characteristics: As follows when tested by a qualified testing agency according to ASTM E 84. Identify products with appropriate markings of applicable testing agency.
   a. Flame-Spread Index: 25 or less.
   b. Smoke-Developed Index: 450 or less.

4. Nominal Thickness: Not less than 0.060 inch.

5. Surface Finish: Smooth.

6. Color: As selected by Architect from manufacturer's full range.

2.3 ACCESSORIES

A. Trim Accessories: Manufacturer's standard one-piece vinyl extrusions designed to retain and cover edges of panels. Provide division bars, inside corners, outside corners, and caps as needed to conceal edges.

B. Adhesive: As recommended by plastic paneling manufacturer.

C. Sealant: Mildew-resistant, single-component, neutral-curing silicone sealant recommended by plastic paneling manufacturer and complying with requirements in Section 079200 "Joint Sealants."
   1. Sealant shall have a VOC content of 250 g/L or less.
   2. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 PREPARATION

A. Remove loose or soluble paint, and other materials that might interfere with adhesive bond.

B. Prepare substrate by sanding high spots and filling low spots as needed to provide flat, even surface for panel installation.

C. Clean substrates of substances that could impair adhesive bond, including oil, grease, dirt, and dust.

D. Condition panels by unpacking and placing in installation space before installation according to manufacturer’s written recommendations.

E. Lay out paneling before installing. Locate panel joints so that trimmed panels at corners are not less than 12 inches wide.
   1. Mark plumb lines on substrate at [trim accessory] [panel joint] locations for accurate installation.
   2. Locate trim accessories to allow clearance at panel edges according to manufacturer's written instructions.

3.3 INSTALLATION

A. Install plastic paneling according to manufacturer's written instructions.

B. Install panels in a full spread of adhesive.

C. Install trim accessories with adhesive.

D. Fill grooves in trim accessories with sealant before installing panels, and bed inside corner trim in a bead of sealant.

E. Maintain uniform space between panels and wall fixtures. Fill space with mildew-resistant sealant.

F. Maintain uniform space between adjacent panels and between panels and floors, ceilings, and fixtures. Fill space with sealant.

G. Remove excess sealant and smears as paneling is installed. Clean with solvent recommended by sealant manufacturer and then wipe with clean dry cloths until no residue remains.

END OF SECTION
SECTION 070413 - COMMON SUBMITTAL REQUIREMENTS FOR THERMAL AND MOISTURE PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor’s risk, provided it complies with the Architect’s notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect’s notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect’s information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

   1. Action Code for Information Only:
      a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.

   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.

   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition

   1. Each submittal consists of items from only ONE Specifications section.
COMMON SUBMITTAL REQUIREMENTS FOR THERMAL AND MOISTURE PROTECTION

2. **Complete Submittal:** If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. **Partial Submittals:** If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. **Submittal Numbering**

1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. **P-Number for Partial Submittals:** Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. **R-Number for Re-submittals:** Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 **SUBMITTAL REVIEW SHEET REQUIREMENTS**

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. **Submittal Number:** See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 071113 - BITUMINOUS DAMPPROOFING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section Includes:
      1. Cold-applied, emulsified-asphalt dampproofing.
      2. Protection course.
   B. Apply dampproofing to surfaces indicated, including:
      1. Concrete foundation walls.
   C. Related Requirements:
      1. Section 030513 "Common Work Results for Cast-in-Place Concrete" for bituminous vapor retarders/barriers under slab.
      2. Section 071326 "Self-Adhering Sheet Waterproofing" for waterproofing.

1.3 ACTION SUBMITTALS
   A. Product Data:  For each type of product.
   B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

1.4 FIELD CONDITIONS
   A. Weather Limitations:  Proceed with application only when existing and forecasted weather conditions permit dampproofing to be performed according to manufacturers' written instructions.
   B. Ventilation:  Provide adequate ventilation during application of dampproofing in enclosed spaces.  Maintain ventilation until dampproofing has cured.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL
   A. Source Limitations:  Obtain primary dampproofing materials and primers from single source from single manufacturer.  Provide protection course auxiliary materials recommended in writing by manufacturer of primary materials.
B. Application Method: Based on substrate, use dampproofing designed for the following application method:
   1. For cast-in-place concrete substrates: Use roller, brush, or trowel, per manufacturer recommendations.

2.2 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. BASF Construction Chemicals - Building Systems; Sonneborn Brand Products; Hydrocide 700.

B. Trowel Coats: ASTM D 1227, Type II, Class 1, fibered.

C. Fibered Brush and Roller Coats: ASTM D 1227, Type II, Class 1.

2.3 AUXILIARY MATERIALS

A. General: Furnish auxiliary materials recommended in writing by dampproofing manufacturer for intended use and compatible with bituminous dampproofing.

B. Primer: As recommended in writing by manufacturer of dampproofing to be applied.

C. Asphalt-Coated Glass Fabric Reinforcement: ASTM D 1668, Type I.

D. Patching Compound: Epoxy or latex-modified repair mortar or Asbestos-free fibered mastic of type recommended in writing by dampproofing manufacturer.

2.4 PROTECTION COURSE

A. Protection Course: Fan folded, with a core of extruded-polystyrene board insulation faced on both sides with plastic film, nominal thickness 1/4 inch, with a compressive strength of not less than 8 psi per ASTM D 1621, and maximum water absorption by volume of 0.6 percent per ASTM C 272.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions with Applicator present, for compliance with requirements for surface smoothness, surface moisture, and other conditions affecting performance of bituminous dampproofing work.

B. Proceed with application only after substrate construction and penetrating work have been completed and unsatisfactory conditions have been corrected.
3.2 PREPARATION

A. Mask or otherwise protect adjoining exposed surfaces from being stained, spotted, or coated with dampproofing. Prevent dampproofing materials from entering and clogging weep holes and drains.

B. Clean substrates of projections and substances detrimental to the dampproofing work; fill voids, seal joints, and remove bond breakers if any, as recommended in writing by prime material manufacturer.

C. Apply patching compound to patch and fill tie holes, honeycombs, reveals, and other imperfections; cover with asphalt-coated glass fabric where required by manufacturer.

3.3 APPLICATION, GENERAL

A. Comply with manufacturer’s written recommendations unless more stringent requirements are indicated or required by Project conditions to ensure satisfactory performance of Dampproofing.

1. Apply primer to affected substrates.
2. Apply first coat of dampproofing over primer.
3. Embed fabric reinforcement into first ply of dampproofing.
4. Apply second coat of dampproofing to required thickness.
5. Apply additional coats if recommended by manufacturer or if required to achieve coverages indicated.
6. Allow each coat of dampproofing to cure per manufacturers written instructions before applying subsequent coats.
7. Allow dampproofing to cure prior to backfilling.

B. Where dampproofing footings and foundation walls, apply from finished-grade line to top of footing; extend over top of footing and down a minimum of 6 inches over outside face of footing.

1. Extend dampproofing 12 inches onto intersecting walls and footings, but do not extend onto surfaces exposed to view when Project is completed.
2. Install flashings and corner protection stripping at internal and external corners, changes in plane, construction joints, cracks, and where shown as “reinforced,” by embedding an 8-inch wide strip of asphalt-coated glass fabric in a heavy coat of dampproofing. Dampproofing coat for embedding fabric is in addition to other coats required.

3.4 INSTALLATION OF PROTECTION COURSE

A. Where indicated, install protection course over completed-and-cured dampproofing. Comply with dampproofing-material and protection-course manufacturers’ written instructions for attaching protection course.

1. Support protection course over cured coating with spot application of adhesive type recommended in writing by protection-board manufacturer.
2. Install protection course after installation of dampproofing (while coating is tacky) to ensure adhesion and as recommended by the dampproofing manufacturer.

3.5 CLEANING

A. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended in writing by manufacturer of affected construction.
END OF SECTION
SECTION 071326 - BELOW-GRADE SHEET WATERPROOFING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Post-applied modified bituminous sheet waterproofing.
   3. Protection course.
   4. Insulation drainage board.

B. Related Requirements:
   1. Section 033000 "Cast-in-Place Concrete" for vertical and horizontal concrete substrate and underslab vapor retarders.
   2. Section 075558 "Fluid-Applied Protected Membrane Roofing" for rooftop plaza-deck waterproofing and pavers.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review waterproofing requirements including surface preparation, substrate condition and pretreatment, adhesion to contaminated substrate (e.g. concrete curing compounds and form release agents), substrate curing period weather related restrictions during installation, special details and sheet flashings, installation procedures, testing and inspection procedures, and protection and repairs. The Contractor: Include the following activities:
      a. Before starting application of membrane waterproofing work, arrange a job-site meeting with the Architect, the Testing Agency and manufacturer representative to discuss the following:
         1) The waterproofing system, number of plies, termination and flashing requirements.
         2) Intermediate and final requirements of protecting the work.
         3) The different substrates that will receive the waterproofing and preparation requirements for each.
         4) Curing requirements for concrete.
         5) Concrete form release agent precautions.
         6) Job specific recommendations on use of primers.
         7) Hot, cold and wet condition precautions.
         8) Scheduling and coordination with other construction, such as waterproofing overlaps that must be installed during construction of walls and footings both above and below grade.
         9) Protection of the work and repair procedures.
10) Verify in writing to the Owner’s representative, that the contractor’s full time on site foreman and crew etc. (as required) are certified, or meet the requirements of the manufacturer of the waterproofing, as installers.

b. Whenever the membrane waterproofing work is to be done, notify Testing Agency in sufficient time to arrange inspections.

c. Provide safe access to the location of the Work for proper inspection.

d. Post installation testing (e.g. Flood Testing or Electronic Field Vector Mapping.)

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, and tested physical and performance properties of waterproofing.
   2. Include manufacturer’s written instructions for evaluating, preparing, and treating substrate.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Show locations and extent of waterproofing and details of substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, and other termination conditions.

D. Samples: For each exposed product and for each color and texture specified, including the following products:
   1. Minimum 8-by-8-inch square of waterproofing and flashing sheet.
   2. Minimum 4-by-4-inch square of drainage panel and protection board.
   3. Minimum 4-by-4-inch (200-by-200-mm) square of each type of insulation board.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by waterproofing manufacturer.

B. Provide the following upon request:
   1. Qualification Data: For Installer.
   2. Manufacturer’s daily field-quality control inspection reports.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Apply waterproofing within the range of ambient and substrate temperatures recommended by waterproofing manufacturer. Do not apply waterproofing to a damp or wet substrate.
   1. Do not apply waterproofing in snow, rain, fog, or mist.

B. Maintain adequate ventilation during preparation and application of waterproofing materials.

C. Compatibility:
1. Where new work interfaces existing waterproofed construction, remove existing waterproofing as required to install new work. Interface new waterproofing with existing system to provide continuous system without leaks. Ensure compatibility of system materials.

2. The waterproofing manufacturer shall submit a letter stating compatibility or concerns with existing, or adjacent, waterproofing.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer's standard materials-only warranty in which manufacturer agrees to furnish replacement waterproofing material for waterproofing that does not comply with requirements or that fails to remain watertight within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Source Limitations for Waterproofing System: Obtain waterproofing materials and molded-sheet drainage panels from single source from single manufacturer.

2.2 POST-APPLIED SHEET WATERPROOFING

A. Modified Bituminous Sheet: Minimum 60-mil nominal thickness, self-adhering sheet consisting of 56 mils of rubberized asphalt laminated on one side to a 4-mil-thick, polyethylene-film reinforcement, and with release liner on adhesive side; formulated for application with primer that complies with VOC limits of authorities having jurisdiction.

1. Basis-of-Design Products: Subject to compliance with requirements, provide Bituthene 3000 or Bituthene 3000 Low Temperature as manufactured by GCP Applied Technologies (formerly Grace Construction Products; W.R. Grace & Co.), or comparable by one of the following:
   a. Carlisle Coatings & Waterproofing Inc.
   b. Henry Company

2. Physical Properties:
   a. Tensile Strength, Membrane: 250 psi minimum; ASTM D 412, Die C, modified.
   b. Ultimate Elongation: 300 percent minimum; ASTM D 412, Die C, modified.
   d. Crack Cycling: Unaffected after 100 cycles of 1/8-inch movement; ASTM C 836.
   e. Puncture Resistance: 40 lbf minimum; ASTM E 154.
   f. Water Absorption: 0.2 percent weight-gain maximum after 48-hour immersion at 70 deg F; ASTM D 570.
   g. Water Vapor Permeance: 0.05 perms maximum; ASTM E 96/E 96M, Water Method.
   h. Hydrostatic-Head Resistance: 200 feet minimum; ASTM D 5385.

2.3 AUXILIARY MATERIALS

A. General: Furnish auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with sheet waterproofing.
1. Furnish liquid-type auxiliary materials that comply with VOC limits of authorities having jurisdiction.

B. Surface Conditioner: Liquid conditioner recommended for substrate by sheet-waterproofing material manufacturer.

C. Primer: Liquid primer recommended for substrate by sheet-waterproofing material manufacturer.

D. Liquid Membrane: Elastomeric, two-component liquid, cold fluid applied, of trowel grade or low viscosity.

E. Substrate Patching Membrane: Low-viscosity, two-component, modified asphalt coating.

F. Sheet Strips: Self-adhering, rubberized-asphalt sheet strips of same material and thickness as sheet waterproofing.

G. Mastic, Adhesives, and Detail Tape: Liquid mastic and adhesives, and adhesive tapes recommended by waterproofing manufacturer.
   1. Detail Tape: Two-sided, pressure-sensitive, self-adhering reinforced tape, 4-1/2 inches wide, with a tack-free protective adhesive coating on one side and release film on self-adhering side.

H. Metal Termination Bars:
   1. Termination Bar: Stainless Steel 1 inch by 8 feet, 0.075" thick, with 5/16" holes 8" to 9" on center. Basis of design: Advanced Building Products Inc. Stainless Steel Termination Bar.
   2. Expansion Anchor: 1/4" x 2" expansion anchor consisting of a Type 304 Stainless Steel drive pin and an expanding body. Basis of design: Hilti Metal HIT Anchor.

I. Protection Course: ASTM D6506, semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners and as follows:
   1. Thickness: Nominal 1/8 inch for vertical applications; 1/4 inch elsewhere.
   2. Adhesive: Rubber-based solvent type recommended by waterproofing manufacturer for protection course type.

2.4 MOLDED-SHEET DRAINAGE PANELS

A. Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel: Composite subsurface drainage panel consisting of a studded, nonbiodegradable, molded-plastic-sheet drainage core; with a nonwoven, needle-punched geotextile facing with an apparent opening size not exceeding No. 70 sieve laminated to one side of the core and a polymeric film bonded to the other side; and with a vertical flow rate of 9 to 18 gpm per ft..
   1. Products: Subject to compliance with requirements, provide products supplied by or approved by membrane manufacturer.
   2. Application: Vertical, below-grade, drainage panel over insulation over protection course over waterproof membrane over concrete foundation.
2.5 INSULATION

A. Drawing Keynote XPS-1: Faced, extruded-polystyrene drainage board insulation complying with ASTM C 578, Type IV, 25-psi minimum compressive strength; faced with filtration fabric; tongue-and-groove edges and with one side having ribbed drainage channels.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Foamular Insul-Drain as manufactured by Owens Corning, or comparable by one of the following:
   a. Dow Sytrofoam Perimate
   b. Kingspan Greenguard


PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the waterproofing.

1. Verify that concrete has cured and aged for minimum time period recommended in writing by waterproofing manufacturer.

2. Verify that substrate is visibly dry and within the moisture limits recommended in writing by manufacturer. Test for capillary moisture by plastic sheet method according to ASTM D 4263.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SURFACE PREPARATION

A. Clean, prepare, and treat substrates according to manufacturer's written instructions. Provide clean, dust-free, and dry substrates for waterproofing application.

B. Mask off adjoining surfaces not receiving waterproofing to prevent spillage and overspray affecting other construction.

C. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.

D. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids.

E. Prepare, fill, prime, and treat joints and cracks in substrates. Remove dust and dirt from joints and cracks according to ASTM D 4258.

1. Install sheet strips of width according to manufacturer's written instructions and center over treated construction and contraction joints and cracks.

F. Bridge and cover discontinuous deck-to-wall and deck-to-deck joints with overlapping sheet strips of widths according to manufacturer's written instructions.

G. Corners: Prepare, prime, and treat inside and outside corners according to ASTM D 6135.
1. Install membrane strips centered over vertical inside corners. Install 3/4-inch fillets of liquid membrane on horizontal inside corners and as follows:
   a. At footing-to-wall intersections, extend liquid membrane in each direction from corner or install membrane strip centered over corner.
   b. At plaza-deck-to-wall intersections, extend liquid membrane or sheet strips onto deck waterproofing and to finished height of sheet flashing.

H. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations through waterproofing and at drains and protrusions according to ASTM D 6135.

3.3 POST-APPLIED VERTICAL SHEET-WATERPROOFING APPLICATION

A. Install modified bituminous sheets according to waterproofing manufacturer's written instructions and recommendations in ASTM D 6135.

B. Apply surface conditioner and primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by sheet waterproofing in same day. Reprim areas exposed for more than 24 hours.

C. Apply reinforcement sheet strips over liquid membrane fillet at transitions from vertical to horizontal planes according to waterproofing manufacturer's written instructions.

D. Apply and firmly adhere sheets, 100 percent back rolled, over area to receive waterproofing. Accurately align sheets and maintain uniform 3-inch minimum lap widths and end laps. Overlap and seal seams, and stagger end laps to ensure watertight installation.

1. When ambient and substrate temperatures range between 25 and 40 deg F, install self-adhering, modified bituminous sheets produced for low-temperature application. Do not use low-temperature sheets if ambient or substrate temperature is higher than 60 deg F.

E. One-Ply Application: Install sheets to form a membrane with lap widths of a uniform 3-inch (64-mm) minimum. Install additional 6-inch wide sheet strips over laps.

F. Apply continuous sheets over already-installed sheet strips, bridging substrate cracks, construction, and contraction joints.

G. Fold extended edges of pre-applied horizontal membranes vertically up foundation surfaces and seal with liquid flashing. Lap vertical membrane over folded portions of horizontal edges adhered to vertical face.

H. Seal edges of sheet-waterproofing terminations with liquid membrane.

I. Install sheet-waterproofing and auxiliary materials to tie into adjacent waterproofing.

J. Fold horizontal pre-applied membranes up vertical foundations. Lap vertical membrane over folded portions

K. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Slit and flatten fishmouths and blisters. Patch with sheet waterproofing extending 6 inches beyond repaired areas in all directions.

L. Install protection course with butted joints adhered to waterproof membrane immediately after membrane installation.
3.4 INSULATION DRAINAGE BOARD INSTALLATION

A. Install insulation drainage board over protection course using membrane manufacturer's detail tape with drainage channels against membrane and arranged so channels align vertically to allow drainage. Do not block channels with tape, mastic, or liquid membrane.

B. Ensure that drainage channels are aligned and free of obstructions.

C. Before installing insulation on vertical walls with spread footings, install strips of molded-sheet drainage panel up wall a minimum of 8 inches at bottom of vertical wall at footing, then horizontally over footing, and down over edge of footing vertically another 4 inches to allow drainage and to prevent accumulation of water on top of footing.

D. Install one or more layers of board insulation to achieve required thickness over waterproofed surfaces. Cut and fit to within 3/4 inch of projections and penetrations and seal with liquid flashing.
   1. If more than one layer is required, use insulation adhesive as instructed by insulation manufacturer for below-grade application.

E. On vertical surfaces, set insulation units with tape applied according to manufacturer's written instructions.

3.5 MOLDED-SHEET DRAINAGE-PANEL INSTALLATION

A. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate, according to manufacturer's written instructions. Use adhesives or other methods that do not penetrate waterproofing. Lap edges and ends of geotextile to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.
   1. For vertical applications with insulation, install molded-sheet drainage panels over insulation over protection course.
   2. For vertical applications without insulation, install molded-sheet drainage panels directly over protection course.

3.6 FIELD QUALITY CONTROL

A. Site Representative: Engage a site representative qualified by waterproofing membrane manufacturer to inspect substrate conditions, surface preparation, membrane application, flashings, protection, and drainage components, and to furnish daily reports to Architect.

3.7 PROTECTION, REPAIR, AND CLEANING

A. Do not permit foot or vehicular traffic on unprotected membrane.

B. Protect waterproofing from damage and wear during remainder of construction period.

C. Protect installed insulation from damage due to UV light, harmful weather exposures, physical abuse, and other causes. Provide temporary coverings where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

D. Correct deficiencies in or remove waterproofing that does not comply with requirements; repair substrates, reapply waterproofing, and repair sheet flashings.
E. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

3.8 BELOW-GRADE WATERPROOFING SCHEDULE

A. System A: Drainage panel over protection course over single layer modified bituminous sheet waterproofing over structural concrete foundation.

B. System B: Drainage panel over extrude polystyrene insulation board (XPS-1) over protection course over single layer modified bituminous sheet waterproofing over structural concrete foundation.

END OF SECTION
SECTION 071413 - HOT FLUID-APPLIED RUBBERIZED ASPHALT WATERPROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Rubberized-asphalt waterproofing membrane for split-slab plaza deck paving.
   2. Electric field vector mapping (EFVM).

B. Related Requirements:
   1. Section 075556 “Fluid-Applied Protected Membrane Roofing” for roof waterproofing with pavers and pedestals.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

   1. Review waterproofing requirements including surface preparation, substrate condition and pretreatment, adhesion to contaminated substrate (e.g. concrete curing compounds and form release agents), substrate curing period weather related restrictions during installation, special details and sheet flashings, installation procedures, testing and inspection procedures, and protection and repairs. The Contractor: Include the following activities:
      a. Before starting application of membrane waterproofing work, arrange a job-site meeting with the Architect, the Testing Agency and manufacturer representative to discuss the following:
         1) The waterproofing system, number of plies, termination and flashing requirements.
         2) Intermediate and final requirements of protecting the work.
         3) The different substrates that will receive the waterproofing and preparation requirements for each.
         4) Curing requirements for concrete.
         5) Concrete form release agent precautions.
         6) Adhering to coated surfaces, if applicable.
         7) Job specific recommendations on use of primers.
         8) Hot, cold and wet condition precautions.
         9) Scheduling and coordination with other construction, such as waterproofing overlaps that must be installed during construction of walls and footings both above and below grade.
         10) Protection of the work and repair procedures.
         11) Verify in writing to the District’s representative, that the contractor’s full time on site foreman and crew etc. (as required) are certified, or meet the requirements of the manufacturer of the waterproofing, as installers.
      b. Whenever the membrane waterproofing work is to be done, notify Testing Agency in sufficient time to arrange inspections.
      c. Provide safe access to the location of the Work for proper inspection.
      d. Post installation testing (e.g. Flood Testing or Electronic Field Vector Mapping.)
1.3 ACTION SUBMITTALS

A. Samples: For the following products:
   1. Waterproofing System, 8 by 8 inches, showing layering of membrane components
      (waterproofing membrane, reinforcing fabric, and protection course).
   2. Flashing sheet, and drainage panel, 8 by 8 inches.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by
   manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store liquid materials in their original undamaged containers in a clean, dry, protected location
   and within the temperature range required by waterproofing manufacturer.

B. Remove and replace liquid materials that cannot be applied within their stated shelf life.

C. Protect stored materials from direct sunlight.

1.6 FIELD CONDITIONS

A. Weather Limitations: Apply waterproofing within the range of ambient and substrate
   temperatures recommended by waterproofing manufacturer. Do not apply waterproofing to a
   damp or wet substrate, or when temperature is below zero deg F.
   1. Do not apply waterproofing in snow, rain, fog, or mist.

B. Maintain adequate ventilation during application and curing of waterproofing materials.

C. Compatibility:
   1. Where new work interfaces existing waterproofed construction, remove existing
      waterproofing as required to install new work. Interface new waterproofing with existing
      system to provide continuous system without leaks. Ensure compatibility of system
      materials.
   2. The waterproofing manufacturer shall submit a letter stating compatibility or concerns
      with existing, or adjacent, waterproofing.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace waterproofing and sheet flashings
   that do not comply with requirements or that fail to remain watertight within specified warranty
   period.
   1. Warranty includes removing and reinstalling protection course and drainage panels.
   2. Warranty Period: Five years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain waterproofing materials insulation and from single source from single manufacturer.

2.2 WATERPROOFING MEMBRANE

A. Hot Fluid-Applied, Rubberized-Asphalt Waterproofing Membrane: Single component; 100 percent solids; hot fluid-applied, rubberized asphalt.

1. Basis-of-design Products: Subject to compliance with requirements, provide Monolithic Membrane 6125 as manufactured by American Hydrotech, Inc., or one of the following comparable products:
   a. Carlisle Coatings & Waterproofing Inc; CCW-500R.
   b. Henry Company; 790-11.
   c. Soprema, Inc.; Colphene H

2.3 AUXILIARY MATERIALS

A. General: Auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with waterproofing.

B. Primer: ASTM D 41/D 41M, asphaltic primer and surface conditioner.

C. Elastomeric Sheet: 50-mil- minimum, uncured sheet neoprene with manufacturer's recommended contact adhesives, if applicable, as follows:
   1. Tensile Strength: 1400 psi minimum; ASTM D 412, Die C.
   2. Elongation: 300 percent minimum; ASTM D 412.
   3. Tear Resistance: 125 psi minimum; ASTM D 624, Die C.

D. Sealants and Accessories: Manufacturer's recommended sealants and accessories.

E. Reinforcing Fabric: Manufacturer's recommended, neoprene or spun-bonded polyester fabric.

F. Liquid Flashing: Manufacturer's recommended, two-component, liquid applied resin membrane flashing system.

G. Adhesive: Manufacturer's recommended contact adhesive for bonding elastomeric flashing.

2.4 MOLDED-SHEET DRAINAGE PANELS

1. Compressive Strength: ASTM D 1621; Not less than 30000 psf
2. Flow Rate: ASTM D 4716; Not less than 7 gpm/ft. width
3. Products: Subject to compliance with requirements, provide the following, or comparable by selected product system manufacturer:
   a. American Hydrotech, Inc; Hydrodrain 300.
B. Protection Course:

1. Fiberglass reinforced rubberized asphalt sheet: Subject to compliance with requirements, provide the following, or comparable by selected product system manufacturer:
   a. American Hydrotech, Inc., Hydroflex 30

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
   1. Verify that concrete has cured and aged for minimum time period recommended by waterproofing manufacturer.
   2. Verify that substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean and prepare substrates according to manufacturer’s written instructions. Provide clean, dust-free, and dry substrate for waterproofing application.

B. Mask off adjoining surfaces not receiving waterproofing to prevent spillage and overspray affecting other construction.

C. Close off deck drains and other deck penetrations to prevent spillage and migration of waterproofing fluids.

D. Remove grease, oil, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.

E. Remove fins, ridges, and other projections, and fill honeycomb, aggregate pockets, and other voids.

3.3 JOINTS, CRACKS, AND TERMINATIONS

A. Prepare and treat substrates to receive waterproofing membrane, including joints and cracks, deck drains, corners, and penetrations according to manufacturer’s written instructions.
   1. Rout and fill joints and cracks in substrate. Before filling, remove dust and dirt according to ASTM D 4258.
   2. Adhere strip of elastomeric sheet to substrate in a layer of hot rubberized asphalt. Extend elastomeric sheet a minimum of 6 inches on each side of moving joints and cracks or joints and cracks exceeding 1/8 inch thick, and beyond deck drains and penetrations. Apply second layer of hot fluid-applied, rubberized asphalt over elastomeric sheet.
   3. Embed strip of reinforcing fabric into a layer of hot rubberized asphalt. Extend reinforcing fabric a minimum of 6 inches on each side of nonmoving joints and cracks not exceeding 1/8 inch thick, and beyond roof drains and penetrations.
a. Apply second layer of hot fluid-applied, rubberized asphalt over reinforcing fabric.

B. At expansion joints and discontinuous deck-to-wall or deck-to-deck joints, bridge joints with elastomeric sheet extended a minimum of 6 inches on each side of joints and adhere to substrates in a layer of hot rubberized asphalt. Apply second layer of hot fluid-applied, rubberized asphalt over elastomeric sheet.

3.4 FLASHING INSTALLATION

A. Install elastomeric sheets at terminations of waterproofing membrane according to manufacturer's written instructions.

B. Prime substrate with asphalt primer/conditioner. Allow to thoroughly dry before application of membrane as instructed by membrane manufacturer.

C. Install elastomeric sheet and adhere to deck and wall substrates in a layer of hot rubberized asphalt.

D. Terminate flashing sheet at terminations and perimeter of waterproofing as instructed by manufacturer to suit condition

3.5 MEMBRANE APPLICATION

A. Apply primer, at manufacturer's recommended rate, over prepared substrate and allow it to dry.

B. Heat and apply rubberized asphalt according to manufacturer's written instructions.
   1. Heat rubberized asphalt in an oil- or air-jacketed melter with mechanical agitator specifically designed for heating rubberized asphalt.

C. Start application with manufacturer's authorized representative present.

D. Reinforced Membrane: Apply hot rubberized asphalt to substrates and adjoining surfaces indicated. Spread to a thickness of 90 mils; embed reinforcing fabric, overlapping sheets 2 inches; spread another 125-mil-thick layer to provide a uniform, reinforced, seamless membrane 215 mils thick.

E. Apply waterproofing over prepared joints and up wall terminations and vertical surfaces to heights indicated or required by manufacturer.

F. Cover waterproofing with protection course with overlapped joints using adhesive before membrane is subject to construction or vehicular traffic.

3.6 MOLDED-SHEET DRAINAGE PANEL INSTALLATION

A. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate according to manufacturer's written instructions. Use methods that do not penetrate waterproofing. Lap edges and ends of geotextile to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.
3.7 FIELD QUALITY CONTROL

A. Site Representative: Engage a full-time site representative qualified by waterproofing membrane manufacturer to inspect substrate conditions; surface preparation; and application of membrane, flashings, protection, and drainage components; furnish daily reports to Architect.

1. Site representative shall measure membrane thickness with pin tester or other suitable device at least once for every 100 sq. ft. and include measurements in reports.

B. Testing Agency: Engage a qualified testing agency to inspect substrate conditions, surface preparation, waterproofing application, protection, and drainage components, and to furnish reports to Architect.

C. Post Installation Testing: All horizontal waterproofed surfaces, except for slab-on-grade applications.

1. Electric Field Vector Mapping (EFVM): EFVM technician shall survey entire waterproofing area for potential leaks using EFVM.
   a. After installing horizontal membrane and before placing overburden or vegetated roof system. Provide testing to verify membrane is free of any holes, open seams, and/or capillary defects that will allow water to pass.
   b. Install a temporary leak detection system by one of the following or approved equal:
      1) Honza Group Incorporated, Columbia, Maryland; 301-953-7210
      2) International Leak Detection, Ltd, Ontario, Canada; 905-438-8283
      3) Vector Mapping IR Analyzers; 800-879-1964
      4) Other testing providers may be considered with approval of the membrane Manufacturer and Architect.
   c. Engage a company experienced in detecting breaches in the waterproofing using an electronic detection system.
   d. Installation of EFVM impulse conductor wire around perimeter of area to be tested.
      1) The testing agency will determine size and shape of area.
      2) The conductor wire will consist of braided interwoven strands of stainless steel wire.
   e. Place wire directly on membrane.
   f. Wet the test area with potable water sufficiently to create a continuous conducting “plate” above the membrane.
   g. The technician providing the EFVM testing shall provide a report of each day’s test results containing:
      1) Written description and photograph of all defects and any corrections made.
      2) A schematic drawing indicating location of stationary conductor wire and of any defects found in testing.
      3) Report shall be made in hard copy and submitted to the Architect and District.
   h. If breaches are discovered, repair the breach and retest the affected area. Repeat this process until no breach is detected.

2. Engage an independent testing agency to observe testing. If breaches are discovered, the independent testing agency shall observe repairs and retesting of discovered breaches.
3.8 CLEANING AND PROTECTION

A. Protect waterproofing from damage and wear during remainder of construction period.

B. Protect installed insulation from damage due to UV light, harmful weather exposures, physical abuse, and other causes. Provide temporary coverings where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

C. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION
SECTION 071619 - METAL OXIDE WATERPROOFING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes metal-oxide waterproofing for negative-side application to concrete.

B. Related Requirements:
   1. Section 033000 "Cast-in-Place Concrete" for waterstops, and finishing concrete walls and slabs to receive waterproofing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions and installation instructions for metal-oxide waterproofing.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

1.4 QUALITY ASSURANCE

A. Applicator Qualifications: A firm experienced in applying metal-oxide waterproofing similar in material, design, and extent to that indicated for this Project, whose work has resulted in applications with a record of successful in-service performance, and that employs workers trained and approved by manufacturer.

B. Submit the following upon request:
   1. Qualification Data: For Applicator.
   2. Product Certificates: For waterproofing, patching, and plugging materials, from manufacturer.
   3. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for metal-oxide waterproofing.
   4. Field quality-control reports.

1.5 PROJECT CONDITIONS

A. Weather Limitations: Proceed with application only when existing and forecasted weather conditions permit metal-oxide waterproofing to be performed according to manufacturer's written instructions.
B. Proceed with waterproofing work only after pipe sleeves, vents, curbs, inserts, drains, and other projections through the substrate to be waterproofed have been completed. Proceed only after substrate defects, including honeycombs, voids, and cracks, have been repaired to provide a sound substrate free of forming materials, including reveal inserts.

C. Ambient Conditions: Proceed with waterproofing work only if temperature is maintained at 40 deg F or above during work and cure period, and space is well ventilated and kept free of water.

PART 2 - PRODUCTS

2.1 WATERPROOFING MATERIALS

A. Metal-Oxide Waterproofing Compound: A product specifically formulated for waterproofing concrete and masonry substrates; containing pulverized iron and a chemical oxidizing agent to cause the iron particles to rust and grow in size in the presence of water; with VOC content complying with limits of authorities having jurisdiction.

1. Products: Subject to compliance with requirements, provide one of the following:
   b. Metalcrete Industries; Metalcrete Waterproofing.
   c. Specco Industries, Inc.; Speccrete Metallic Waterproofer.

2.2 ACCESSORY MATERIALS

A. Patching Compound: Factory-premixed cementitious repair mortar, crack filler, or sealant recommended by waterproofing manufacturer for filling and patching tie holes, honeycombs, reveals, and other imperfections; compatible with substrate and other materials indicated; and VOC content complying with limits of authorities having jurisdiction.

B. Plugging Compound: Factory-premixed cementitious compound with hydrophobic properties and recommended by waterproofing manufacturer; resistant to water and moisture but vapor permeable for all standard applications (vertical, overhead, and horizontal surfaces not exposed to vehicular traffic); compatible with substrate and other materials indicated; and VOC content complying with limits of authorities having jurisdiction.

C. Portland Cement: ASTM C 150, Type I.

D. Sand: ASTM C 144.

E. Water: Potable.

2.3 MIXES

A. Metal-Oxide Waterproofing Compound: Add metal oxide waterproofing components, pre mixed or field mixed, per manufacturer’s written instructions. Blend together with mechanical mixer or by hand to required consistency for each coat.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Applicator present, for suitable conditions where waterproofing is to be applied.

B. Proceed with application only after unsatisfactory conditions have been corrected.

C. Notify Architect in writing of active leaks or defects that would affect system performance.

3.2 PREPARATION

A. Protect other work from damage caused by cleaning, preparation, and application of waterproofing. Provide temporary enclosure[ to confine spraying operation and] to ensure adequate ambient temperatures and ventilation conditions for application.

B. Do not allow waterproofing, patching, and plugging materials to enter reveals or annular spaces intended for resilient sealants or gaskets, such as joint spaces between pipes and pipe sleeves.

C. Stop active water leaks with plugging compound according to waterproofing manufacturer's written instructions.

D. Repair damaged or unsatisfactory substrate with patching compound according to manufacturer's written instructions.
   1. At holes and cracks in substrate, remove loosened chips and cut reveal with sides perpendicular to surface, not tapered, and approximately 1 inch deep. Fill reveal with patching compound flush with surface.

E. Surface Preparation: Comply with waterproofing manufacturer's written instructions to remove efflorescence, chalk, dust, dirt, mortar spatter, grease, oils, paint, curing compounds, and form-release agents to ensure that waterproofing bonds to surfaces.
   1. Clean concrete surfaces according to ASTM D 4258.
      a. Mechanical abrading or abrasive-blast cleaning according to ASTM D 4259.

F. Comply with waterproofing manufacturer's written requirements, if any, regarding moisture content, moisture and RH testing, and remediation of moisture if required in concrete to ensure that waterproofing bonds to surfaces.

3.3 APPLICATION

A. General: Comply with waterproofing manufacturer's written instructions for application and curing.
   1. As recommended by the manufacturer, saturate surface with water and maintain in a damp condition until applying waterproofing. Remove standing water.
   2. Apply waterproofing to surfaces indicated on Drawings.
   3. Number of Metal-Oxide Coats: Three.
   4. Application Method: Brush apply the waterproofing, vigorously working first coat onto the substrate and forcing the material into surface voids. Brush each subsequent coat into full contact with previous coat.
5. Dampen surface between coats.
6. Allow each coat to cure before applying subsequent coats.

B. Curing: Moist-cure waterproofing per manufacturer's requirements after final coat has set, followed by air drying prior to being placed in service, unless otherwise recommended in writing by manufacturer.

C. Waterproofing Treatment Extensions: Extend waterproofing treatment as follows:
1. Onto every substrate in areas indicated for treatment, including pits, sumps and similar offsets and features.

3.4 FIELD QUALITY CONTROL

A. Inspection: Engage manufacturer's representative to inspect completed application and provide a written report that application complies with manufacturer's written instructions.

END OF SECTION
SECTION 072100 - THERMAL INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Rigid foam-plastic board insulation.
   2. Semi-rigid glass-fiber board insulation.
   5. Spray polyurethane foam insulation.
   6. Thermal spacers.

B. Related Requirements:
   1. Section 042113 "Brick Masonry" for installation in metal-framed assemblies of insulation specified by referencing this Section used as part of brick veneer wall assemblies.
   2. Section 061600 "Sheathing" for exterior wall sheathings and wall sheathing joint-and-penetration treatments.
   3. Section 071326 "Below-Grade Sheet Waterproofing" for insulation used in below-grade foundation waterproofing system.
   4. Section 072726 "Membrane Air Barriers" for water-resistive air barrier used as part of an approved NFPA 285 compliant wall assembly.
   5. Section 074213.23 "Metal Wall Panels" for installation in metal-framed assemblies of insulation specified by referencing this Section used as part of an approved NFPA 285 compliant wall assembly.
   6. Section 075419 "Polyvinyl-Chloride (PVC) Roofing" for insulation specified as part of roofing construction.
   7. Section 075556 "Fluid-Applied Protected Membrane Roofing" for insulation used in roof paving system.
   8. Section 078443 "Joint Firestopping and Firesafing" for insulation installed as part of a perimeter fire-resistive joint system.
   9. Section 092400 "Cement Plastering" for installation in metal-framed assemblies of insulation specified by referencing this Section used as part of an approved NFPA 285 compliant wall assembly.
   10. Section 098100 "Acoustical Insulation" for insulation for sound-rated partitions and ceilings.

1.2 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data and Samples submittal. Ensure compliance with requirements included in Division 01 "Submittal Procedures."

B. Product Data: For each type of product indicated.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.
1.3 INFORMATIONAL SUBMITTALS

A. Certification: Manufacturer's certificate of compliance with NFPA 285 for each component.

B. Fire Test Reports: Test reports indicating use of each product as part of an NFPA 285 compliant assembly.

C. Research/Evaluation Reports: For foam-plastic insulation, from ICC-ES.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

B. Provide the following upon request:
   1. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each product.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Project site in their original containers or packages or bundles bearing label clearly identifying manufacturer's name, brand, grade, UL listing, and other pertinent information.

B. Protect insulation materials from physical damage and from deterioration due to moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer's written instructions for handling, storing, and protecting during installation.

C. Protect foam-plastic board insulation as follows:
   1. Do not expose to sunlight except to necessary extent for period of installation and concealment.
   2. Protect against ignition at all times. Do not deliver foam-plastic board materials to Project site before installation time.
   3. Quickly complete installation and concealment of foam-plastic board insulation in each area of construction.

PART 2 - PRODUCTS

2.1 FIRE PERFORMANCE REQUIREMENTS

A. Fire Propagation Characteristics: Where indicated, insulation used in exterior wall assemblies and associated components shall have passed NFPA 285 testing as part of an approved assembly. Substitution of listed products, if approved by Architect as an equal, shall be with comparable products meeting same fire propagation requirements as a component in a listed assembly tested and approved by Underwriter Laboratories, Inc. or another third party testing agency acceptable to the governing authority. Engineering Judgments prepared by the manufacturer shall be preapproved by the authority having jurisdiction.
B. It is not the intention to preclude the use of other comparable products as approved by the Architect, as long as the product meets the criteria and complies with NFPA 285 as part of an approved assembly. Substitution requests shall include certification and technical data from the manufacturer indicating that the product has been tested and approved in a listed assembly. Components of an approved NFPA 285-compliant air-barrier assembly include the following:

1. Plaster Assembly: Water-resistant-barrier on exterior glass-mat-faced sheathing on metal studs, extruded polystyrene insulation drainage board, lath and minimum 3/4 inch thick cement plaster, similar or equal to UL EWS0027 or EWS0030.
2. Metal Wall Panel Assembly: Water-resistant-barrier on exterior glass-mat-faced sheathing on metal studs, mineral-wool cavity insulation board, noncombustible subframing, aluminum panel wall cladding, similar or equal to Intertek Design No. RI/MFF 30-01

2.2 FOAM-PLASTIC BOARD INSULATION

A. Drawing Keynote Type XPS: Extruded-Polystyrene Board Insulation, ASTM C 578 Type IV or better, of minimum compressive strength and properties indicated below; thickness and width indicated and manufacturer's standard length as required to suit job conditions; with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E 84.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Foamular 250 as manufactured by Owens Corning, or comparable by one of the following tested and approved products as part of an NFPA 285 compliant assembly:
   a. DiversiFoam Products.
   b. Dow Chemical Company (The).
   c. Kingspan GreenGaurd (formerly Pactiv Building Products).

2. Physical and Performance Properties: Comparable products meeting the following requirements may be approved by the Architect for use on the Project:
   a. Density: Not less than 1.55 pcf
   b. Compressive Strength: Not less than 25 psi.
   c. Thermal Resistance: R-Value of not less than 10 (deg. F.h.sf/Btu) for 2 inch thickness at 75 deg F mean temperature.

   1) It is not the intention to preclude the use of other comparable products as approved by the Architect, however, for substitution requests to be approved, the product must meet the above criteria. Substitution requests shall include certification and technical data from the manufacturer indicating that the product has been tested and approved in a listed NFPA-compliant assembly.

3. Application: Required for use as rigid substrate behind lath and plaster.

B. NFPA 285-Compliant Option to XPS: Molded-Polystyrene (Expanded) Board Insulation, ASTM C 578, Type II or better, of minimum compressive strength and properties indicated below; thickness and width indicated and manufacturer's standard length as required to suit job conditions; with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E 84.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Neopor GPS Plus as manufactured by Master Builders Solutions (formerly BASF), or comparable by one of the following tested and approved products as part of an NFPA 285 compliant assembly:
   a. DiversiFoam Products.
b. Insulfoam; Carlisle Construction Materials Company.

2. Physical and Performance Properties: Comparable products meeting the following requirements may be approved by the Architect for use on the Project:
   a. Density: Not less than 1.33 pcf
   b. Compressive Strength: Not less than 15 psi.
   c. Thermal Resistance: R-Value of not less than 8 (deg. F.h.sf/Btu) for 2 inch thickness at 75 deg F mean temperature.

1) It is not the intention to preclude the use of other comparable products as approved by the Architect, however, for substitution requests to be approved, the product must meet the above criteria. Substitution requests shall include certification and technical data from the manufacturer indicating that the product has been tested and approved in a listed NFPA-compliant assembly.

C. Drawing Keynote Type XPS-1: See below-grade waterproofing section.

D. Drawing Keynote Type XPS-2: See protected membrane roofing section for insulation under pavers.

2.3 GLASS-FIBER BOARD CURTAIN WALL INSULATION

A. Unfaced, Semi-Rigid Glass-Fiber Board Curtain-Wall Insulation: ASTM C 612, Type IA; thickness as indicated with width and length as required to suit job conditions; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, per ASTM E 84.
   1. Nominal Density of 2.25 lb/cu. ft.
   2. Thermal Resistance: R-Value of 4.3 deg F x h x sq. ft./Btu per inch at 75 deg F.

2.4 MINERAL-WOOL BOARD INSULATION

A. Inorganic, Non-Combustible Mineral-Wool Rain Screen/Cavity Wall Insulation: Unfaced, ASTM C 612, Type IVB; thickness as indicated with width and length as required to suit job conditions; with maximum flame-spread and smoke-developed indexes of zero and zero, respectively, per ASTM E 84; passing ASTM E 136 for combustion characteristics.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide CavityRock as manufactured by Rockwool (formerly Roxul, Inc.), or Architect approved equal by the following:
      a. Owens Corning
   2. Physical and Performance Properties: Comparable products meeting the following requirements may be approved by the Architect for use on the Project:
      a. Thermal Resistance: Of total thickness indicated based on the following per ASTM C 518:
         1) Thermal Resistivity: R-Value per inch at mean temperature of 75 deg F shall not be less than 4.3 (deg. F.h.sf/Btu).
      b. Density: ASTM C 303; Not less than 4.3 lb/cu. ft. for 2-inch thick board.
1) It is not the intention to preclude the use of other comparable products as approved by the Architect, however, for substitution requests to be approved, the product must meet the above criteria. Substitution requests shall include certification and technical data from the manufacturer indicating that the product has been tested and approved in a listed NFPA-compliant assembly.

3. Application: Required for use in exterior rain screen applications behind metal wall cladding with thermal spacers per Section 074213 and behind cement board thin brick substrate with thermal spacers per Section 042113.

2.5 MINERAL-WOOL BLANKET (BATT) INSULATION

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Fibrex Insulations Inc.
2. Owens Corning.
3. Roxul Inc.
4. Thermafiber.

B. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 60 percent.

C. Unfaced, Mineral-Wool Blanket Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers; thickness as indicated with width and length as required to suit job conditions; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, per ASTM E 84; passing ASTM E 136 for combustion characteristics.

1. Minimum density of 0.6 lbs. per cubic foot.
2. Minimum thermal resistivity (R) of 3.1deg F x h x sq. ft./Btu x in. at mean temperature of 75 degrees F.

2.6 SPRAY POLYURETHANE FOAM INSULATION

A. PU-1: Closed-Cell Polyurethane Foam Insulation: ASTM C 1029, Type II, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E 84.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. BASF Corporation.
   b. BaySystems NorthAmerica, LLC.
   c. Dow Chemical Company (The).
   d. Gaco Western Inc.
   e. Henry Company.

2. Minimum density of 1.5 lb/cu. ft., thermal resistivity of 6.2 deg F x h x sq. ft./Btu x in. at 75 deg F.
2.7 COMPOSITE FRAMING SUPPORT SYSTEM

A. Thermal Spacer Type: Thermally-broken, noncombustible composite fiberglass-reinforced polymer z-shaped girts with fully-engaged metal fastener inserts and integral compression seals.

B. Basis of Design Product: Subject to compliance with requirements, provide the following or Architect approved equal.
   1. Advanced Architectural Products; Smartci Greengirt

C. Girt Spacing: Comply with manufacturer's instructions to suit cladding panel sizes and configuration as indicated.

D. Fire Propagation Characteristics: Attachment system shall be tested and approved as part of an NFPA 285 compliant assembly.

E. Fasteners: Self-tapping screws.
   1. Fastener Spacing: Comply with manufacturer's written instructions, but no more than 16 inches on center.
   2. Embedment Depth: Comply with manufacturer's written instructions.
   3. Seal fastener penetrations to maintain air barrier integrity.

F. Attachment Accessories:
   1. Bracing, Furring, Bridging, Plates, and Clips: Formed sheet steel, thickness as necessary to meet structural requirements for special conditions encountered.

2.8 INSULATION FASTENERS AND ADHESIVE

A. Mechanically Attached, Spindle-Type Anchors: Plate welded to projecting spindle; capable of holding insulation of specified thickness securely in position indicated with self-locking washer in place.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. AGM Industries, Inc.; Series T TACTOO Insul-Hangers.
      b. Gemco; Spindle Type.
   2. Plate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   3. Spindle: Corrosion-resistant coated, low-carbon steel; fully annealed; 0.105 inch in diameter; length to suit depth of insulation indicated.

B. Adhesively Attached, Spindle-Type Anchors: Plate welded to projecting spindle; capable of holding insulation of specified thickness securely in position indicated with self-locking washer in place.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. AGM Industries, Inc.; Series T TACTOO Insul-Hangers.
      b. Gemco; Spindle Type.
   2. Plate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   3. Spindle: Copper-coated, low-carbon steel; fully annealed; 0.105 inch in diameter; length to suit depth of insulation indicated.
C. Adhesively Attached, Angle-Shaped, Spindle-Type Anchors: Angle welded to projecting spindle; capable of holding insulation of specified thickness securely in position indicated with self-locking washer in place.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Gemco; 90-Degree Insulation Hangers.

2. Angle: Formed from 0.030-inch thick, perforated, galvanized carbon-steel sheet with each leg 2 inches square.

3. Spindle: Corrosion-resistant coated, low-carbon steel; fully annealed; 0.105 inch diameter; length to suit depth of insulation indicated.

D. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick galvanized-steel sheet, with beveled edge for increased stiffness, sized as required to hold insulation securely in place, but not less than 1-1/2 inches square or in diameter.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. AGM Industries, Inc.; RC150.
   b. Gemco; Dome-Cap or R-150.

2. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in the following locations:
   a. Crawl spaces.
   b. Ceiling plenums.
   c. Attic spaces.
   d. Where indicated.

E. Anchor Adhesive: Product with demonstrated capability to bond insulation anchors securely to substrates indicated without damaging insulation, air barrier, fasteners, and substrates. When in contact with air barrier, provide adhesive and chemical compatible material that is acceptable by the air barrier manufacturer.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Dow Corning Corp.
   b. Momentive Performance Materials, Inc.
   c. Tremco Incorporated

2. Adhesion Strength: 15 lbf/sq. in. minimum.

F. Insulation Adhesive: Insulation manufacturer's recommended bead-applied, low-rise, one- or multi-component urethane adhesive formulated to attach insulation to substrate.

1. Product with demonstrated capability to bond insulation securely to substrates without damaging insulation and substrates.

2. Adhesive shall be compatible with water-resistive barrier products installed over exterior sheathing.
PART 3 - EXECUTION

3.1 PREPARATION

A. Clean substrates of substances that are harmful to insulation or that interfere with insulation attachment.

3.2 INSTALLATION, GENERAL

A. Comply with insulation manufacturer's written instructions applicable to products and applications indicated.

B. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed to ice, rain, or snow at any time.

C. Extend insulation to envelop entire area to be insulated. Cut and fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.

D. Provide sizes to fit applications indicated and selected from manufacturer's standard thicknesses, widths, and lengths. Apply single layer of insulation units to produce thickness indicated unless multiple layers are otherwise shown or required to make up total thickness.

3.3 INSTALLATION OF RAIN SCREEN/CAVITY-WALL INSULATION WITH COMPOSITE FRAMING SUPPORT SYSTEM

A. Install thermal spacers in accordance with manufacturer's installation instructions.

B. Fasten thermal spacers through sheathing directly into steel framing or reinforcing using low-profile 1/4 inch #14 fasteners, maximum 16 inches on center, of sufficient diameter and loading capacity for the application, utilizing the pre-drilled holes in the metal retention plates.
   1. Vertical Applications: Fasten composite girts vertically at each stud or into metal backing. Install girts plumb and properly spaced to ensure retention of mineral wool insulation. Adhesively attach insulation to substrate with vertical ribbons of insulation adhesive.
   2. Horizontal Applications: Install composite girts horizontally level and properly spaced over fiberglass shims to allow drainage behind girt. Fasten to each stud or into metal backing. Provide minimum 3/16 inch weep space without sealant at girt end butt connections.

C. Seal fastener penetrations in water-resistive barriers prior to installation of insulation boards.

D. Install system to fill-in exterior spaces without gaps or voids. Do not compress insulation panels.

E. Trim insulation neatly to fit spaces, and insulate miscellaneous gaps and voids.

F. Fit insulation with edges butted tightly. Fit insulation tightly between thermal spacers and around cladding attachments, penetrations, and other obstructions. Fill voids with spray-applied polyurethane foam sealant.

G. Ensure and verify permanent retention of continuous insulation prior to installing exterior cladding systems.
3.4 INSTALLATION OF RIGID BOARD INSULATION BEHIND PLASTER

A. Foam-Plastic Insulation: Adhesively attach to substrate with vertical ribbons of insulation adhesive. Fit insulation with edges butted tightly. Fit insulation tightly around cladding attachments, thermal spacers and other obstructions.

3.5 INSTALLATION OF BATT INSULATION FOR FRAMED CONSTRUCTION

A. Apply insulation units to substrates by method indicated, complying with manufacturer’s written instructions. If no specific method is indicated, bond units to substrate with adhesive or use mechanical anchorage to provide permanent placement and support of units.

B. Glass-Fiber or Mineral-Wool Blanket Insulation: Install in cavities formed by framing members according to the following requirements:

1. Use insulation widths and lengths that fill the cavities formed by framing members. If more than one length is required to fill the cavities, provide lengths that will produce a snug fit between ends.
2. Place insulation in cavities formed by framing members to produce a friction fit between edges of insulation and adjoining framing members and/or building construction with no gaps or voids.
3. Secure insulation blankets to framing members with fasteners as recommended by the insulation manufacturer.
4. Maintain 3-inch (76-mm) clearance of insulation around recessed lighting fixtures not rated for or protected from contact with insulation.
5. Install eave ventilation troughs between roof framing members in insulated attic spaces at vented eaves.
6. For metal-framed wall cavities where cavity heights exceed 96 inches (2438 mm), support unfaced blankets mechanically and support faced blankets by taping flanges of insulation to flanges of metal studs.
   a. Provide galvanized metal mesh as required to hold insulation blankets in place without sagging.

3.6 MISCELLANEOUS VOIDS

A. Miscellaneous Voids: Install insulation in miscellaneous voids and cavity spaces where required to prevent gaps in insulation using the following materials, matching adjacent insulation type where possible:

1. Unfaced glass-fiber blanket insulation. ASTM C 665, Type I; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, per ASTM E 84; passing ASTM E 136 for combustion characteristics.
2. Unfaced mineral-wool blanket insulation. ASTM C 665, Type I; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, per ASTM E 84; passing ASTM E 136 for combustion characteristics.
3. Glass-Fiber Loose-Fill Insulation: ASTM C 764, Type II; with maximum flame-spread and smoke-developed indexes of 5, per ASTM E 84. Compact to approximately 40 percent of normal maximum volume equaling a density of approximately 2.5 lb/cu. ft. (40 kg/cu. m).
4. Spray Polyurethane Insulation: Apply according to manufacturer’s written instructions. Do not apply insulation until installation of pipes, ducts, conduits, wiring, and electrical outlets in walls is completed and windows, electrical boxes, and other items not indicated to receive insulation are masked.
3.7 INSTALLATION OF CURTAIN-WALL INSULATION

A. Install board insulation in curtain-wall construction where indicated on Drawings according to curtain-wall manufacturer's written instructions.

1. Hold insulation in place by securing metal clips and straps or integral pockets within window frames, spaced at intervals recommended in writing by insulation manufacturer to hold insulation securely in place without touching spandrel glass. Maintain cavity width of dimension indicated between insulation and glass.

2. Install insulation where it contacts perimeter fire-containment system to prevent insulation from bowing under pressure from perimeter fire-containment system.

3.8 PROTECTION

A. Protect installed insulation from damage due to harmful weather exposures, physical abuse, and other causes. Provide temporary coverings or enclosures where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

3.9 INSULATION SCHEDULE

A. When not indicated on Drawings, the following shall perform as a general guideline for applications of different types of insulation:

2. Exterior Walls (Stud Wall Cavity): Unfaced, mineral wool blanket.
3. Exterior Walls (Rainscreen, with thermal spacers): Unfaced semi-rigid mineral wool board.
4. Exterior Walls (Concealed; Plaster): Unfaced rigid XPS board.
5. Voids, Penetrations, Gaps in Exterior Envelope: Spray Polyurethane Foam

END OF SECTION
SECTION 072726 - MEMBRANE AIR BARRIERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Fluid-applied, vapor-retarding membrane air barriers.
   3. Transition membranes.

B. Related Requirements:
   1. Section 042113 "Brick Masonry" for use of air barriers as part of masonry veneer wall cavity and thin brick assemblies.
   2. Section 061600 "Sheathing" for exterior wall sheathings and wall sheathing joint-and-penetration treatments.
   3. Section 072100 "Thermal Insulation" for insulation board used as part of an approved NFPA 285 compliant wall assembly.
   4. Section 074213.23 "Metal Wall Panels" for exterior cladding used as part of an approved NFPA 285 compliant wall assembly.
   5. Section 076200 "Sheet Metal Flashing and Trim" for high-temperature self-adhering membrane flashing and underlayment.
   6. Section 092400 "Cement Plastering" for lath and plaster used as part of an approved NFPA 285 compliant wall assembly.

1.3 DEFINITIONS

A. Air-Barrier Material: A primary element that provides a continuous barrier to the movement of air and moisture. Also, known as water-resistive barrier (WRB).

B. Air-Barrier Accessory: A transitional component of the air barrier that provides continuity.

C. Air-Barrier Assembly: The collection of air-barrier materials and accessory materials applied to an opaque wall, including joints and junctions to abutting construction, to control air movement through the wall.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Include installers of other construction connecting to air barrier, including roofing, sheathing, waterproofing, sealants, plastering, metal wall cladding, glazed curtain walls, storefront windows, and door frames.
2. Review air barrier requirements including surface preparation, substrate condition and pretreatment, minimum substrate curing period, forecasted weather conditions, special details and sheet flashings, mockups, installation procedures, sequence of installation, testing and inspecting procedures, materials approved for use, compatibility of materials, coordination with installation of adjacent and covering materials, and protection and repairs.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product. Include manufacturer's written instructions for evaluating, preparing, and treating substrate; technical data; and tested physical and performance properties of air barrier.
   1. Include manufacturer's written instructions for evaluating, preparing, and treating substrate; technical data; and tested physical and performance properties of products.
   2. Submit letter from primary materials manufacturer indicating approval of products not manufactured by primary manufacturer.
   3. Include statement from manufacturer that product has been tested in an approved assembly and meets the requirements of NFPA 285.
   4. Include statement that materials are compatible with adjacent materials proposed for use.
   5. Submit reports indicating that field peel-adhesion test on all materials to which sealants are adhered have been performed and the changes made, if required, to other approved materials, in order to achieve successful adhesion.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For air-barrier assemblies.
   1. Show locations and extent of air barrier. Include project specific details for substrate joints and cracks, counterflashing strips, penetrations, inside and outside corners, terminations, and tie-ins with adjoining construction.
   2. Include project specific details of interfaces with other materials that form part of air barrier.
   3. Include letter from manufacturer indicating that the project specific details and shop drawings have been reviewed and are approved for use.

D. Samples: Submit clearly labeled samples, 3 by 4 inch minimum size of each material specified.

1.6 INFORMATIONAL SUBMITTALS

A. Certification: Manufacturer's certificate of compliance with NFPA 285 for each component.

B. Fire Test Reports: Test reports indicating use of each product as part of an NFPA 285 compliant assembly.

C. Product Test Reports: For each air-barrier assembly, for tests performed by a qualified testing agency.

D. Field Test Results: Submit mockup and in-situ test results of air leakage test and water leakage test with specified standards, including retesting if initial results are not satisfactory.

E. Qualification Data: For Installer. Include list of ABAA-certified installers and supervisors employed by the Installer, who work on Project.
1. Provide evidence from the manufacturer that the firm is approved, authorized, or licensed to install the specified products and is eligible to receive manufacturer's special warranty.

2. Provide evidence that the installing firm is experienced in applying air barrier materials similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.

3. Provide a manual that describes Installers and Manufacturers Quality Assurance / Quality Control program and procedures.

4. Submit evidence of current accreditation and certification under the Air Barrier Association of America’s (ABAA) Quality Assurance Program. Submit accreditation number of manufacturer and certification number of installers.

F. Product Certificates: From air-barrier manufacturer, certifying permanent chemical and adhesive compatibility of air barriers and accessory materials with Project materials that connect to or that come in contact with the barrier, and certifying that cleaning materials used during installation are chemically compatible with each of the adjacent materials proposed for use.

G. Product Test Reports: For each air-barrier assembly, for tests performed by a qualified testing agency.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. A qualified firm that is approved, authorized, or licensed by the manufacturer to install manufacturer's product, that is eligible to receive manufacturer's special warranty, and is experienced in applying air barrier materials similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.

2. A firm that is an ABAA-licensed contractor and employs certified and registered installers.

3. A firm that complies with ABAA's Quality Assurance Program.

4. Installer shall be licensed by ABAA according to ABAA's Quality Assurance Program and shall employ ABAA-certified installers and supervisors on Project.

B. Manufacturer Qualifications: A qualified manufacturer regularly engaged in manufacturing air barrier membranes.

C. Quality Assurance / Quality Control Program:

1. Implement the ABAA Quality Assurance Program requirements. Cooperate with ABAA inspectors and independent testing and inspection agencies engaged by the District. Do not cover air barrier until it has been inspected, tested and accepted.

2. Daily Inspection:

   a. Visual inspection of the substrate prior to the application of membrane to confirm the substrate is in accordance with the manufacturer’s instructions.

   b. Visual inspection on the completed air barrier for that day and fix any deficiencies.

   c. Verification of manufactures specific Wet film thickness of installed work.

   d. Adhesion Test as indicated in Field Quality Control.

3. Daily Work Sheet: At a minimum include the following:

   a. Listing of installers

   b. Project name

   c. Type of air barrier installed

   d. Air barrier product name and lot/batch number

   e. Primer product name and lot/batch number
f. Substrate type

g. Substrate preparation required

h. Installation locations (gridlines, elevations, etc)

i. Results of visual inspection

j. Results of verification of wet film thickness, include photo documentation

k. Results of verification of adhesion testing, include photo documentation

4. Testing, Inspection, and Reporting as indicated in the Field Quality control.

D. Mockups: Before beginning installation of air barrier, build mockups to set quality standards for materials and execution and for preconstruction testing.

1. Build mockups of exterior wall assembly [as shown on Drawings] [150 sq. ft.] <Insert area or dimensions>, incorporating backup wall construction, external cladding, window, storefront, door frame and sill, insulation, ties and other penetrations, and flashing to demonstrate surface preparation, crack and joint treatment, application of air barriers, and sealing of gaps, terminations, and penetrations of air-barrier assembly.

   a. Coordinate construction of mockups to permit inspection by District's testing agency of air barrier before external insulation and cladding are installed.

   b. Include junction with roofing vapor retarder, building corner condition, and below-grade waterproofing where applicable.

   c. If Architect determines mockups do not comply with requirements, reconstruct mockups and apply air barrier until mockups are approved.

2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: District will engage a qualified testing agency to perform preconstruction testing on field mockups.

B. Mockup Testing: Include air barrier assemblies in standalone exterior envelope mockup wall assemblies with preconstruction testing requirements. Air-barrier assemblies shall comply with performance requirements indicated, as evidenced by reports based on mockup testing by a qualified testing agency. In addition, provide the following:

   1. Adhesion Testing: Mockups will be tested for minimum air-barrier adhesion of 16 lbf/sq. in. or to manufacturer's minimum adhesion level per substrates, whichever is greater, according to ASTM D 4541.

      a. Test Locations: Perform 3 tests per substrate type.

C. Notify Architect 14 days in advance of the dates and times when mockups will be tested.

D. Preconstruction Sealant Testing: Submit samples of air barrier materials that will contact joint sealants, or materials that may be affected by joint sealants, to joint-sealant manufacturer. Joint-sealant manufacturer will test elastomeric sealants for adhesion to and compatibility with air barrier materials.

   1. Testing will not be required if data is submitted based on previous testing of current sealant products and air barrier materials matching those submitted.

   2. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
3. For materials failing tests, sealant manufacturer shall submit written instructions for corrective measures including the use of specially formulated primers.
4. Refer to Section 079000 "Joint Sealants" for further instructions and additional information.

E. DELIVERY, STORAGE, AND HANDLING

F. Remove and replace liquid materials that cannot be applied within their stated shelf life.

G. Protect stored materials from direct sunlight.

1.9 FIELD CONDITIONS

A. Environmental Limitations: Apply air barrier within the range of ambient and substrate temperatures recommended by air-barrier manufacturer.
   1. Protect substrates from environmental conditions that affect air-barrier performance.
   2. Do not apply air barrier to a damp or wet substrate or during snow, rain, fog, or mist.

1.10 WARRANTY

A. Manufacturer's Warranty: Provide manufacturer's standard product warranty, for a minimum 10 years from date of Substantial Completion.

B. Special Installer's Warranty: Provide air barrier installer's 2 year warranty from date of Substantial Completion, including all components of the air barrier assembly, against failures including loss of air tight seal, loss of watertight seal, loss of adhesion, loss of cohesion, failure to cure properly.

PART 2 - PRODUCTS

2.1 FIRE PERFORMANCE REQUIREMENTS

A. Fire Propagation Characteristics: Where indicated, water-resistive air barriers and associated components shall have passed NFPA 285 testing as part of an approved assembly. Substitution of listed products, if approved by Architect as an equal, shall be with comparable products meeting same fire propagation requirements as a component in a listed assembly tested and approved by Underwriter Laboratories, Inc. or another third party testing agency acceptable to the governing authority. Engineering Judgments prepared by the manufacturer shall be preapproved by the authority having jurisdiction.

B. It is not the intention to preclude the use of other comparable products as approved by the Architect, as long as the product meets the criteria and complies with NFPA 285 as part of an approved assembly. Substitution requests shall include certification and technical data from the manufacturer indicating that the product has been tested and approved in a listed assembly. Components of an approved NFPA 285-compliant air-barrier assembly include the following:
   1. Plaster Assembly: Water-resistive-barrier on exterior glass-mat-faced sheathing on metal studs, extruded polystyrene insulation drainage board, lath and minimum 3/4 inch thick cement plaster, equal to UL EWS0027 primary system or EWS0025 comparable system.
2. Metal Wall Panel Assembly: Water-resistive-barrier on exterior glass-mat-faced sheathing on metal studs, mineral-wool cavity insulation board, noncombustible subframing, aluminum panel wall cladding, similar or equal to Intertek Design No. RI/MFF 30-01.

2.2 GENERAL PERFORMANCE REQUIREMENTS

A. Air barrier shall be capable of performing as a continuous vapor-permeable air barrier and as a liquid-water drainage plane flashed to discharge to the exterior incidental condensation or water penetration. Air-barrier assemblies shall be capable of accommodating substrate movement and of sealing substrate expansion and control joints, construction material changes, penetrations, tie-ins to installed waterproofing, and transitions at perimeter conditions without deterioration and air leakage exceeding specified limits.

B. Provide an air barrier assembly that withstands combined positive and negative design wind, fan and stack pressures on the envelope without damage or displacement, that transfers the load to the structure, and that does not displace adjacent materials under full load. Join air barrier system materials in an airtight and flexible manner to adjacent assemblies, allowing for the relative movement of assemblies due to thermal and moisture variations and creep, and anticipated seismic movement.

2.3 FLUID-APPLIED MEMBRANE AIR BARRIER - PRIMARY MEMBRANE

A. Fluid-Applied, Vapor-Retarding Membrane Air Barrier, Type 1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide ExoAir 130 as manufactured by Tremco Inc., or comparable of the following, or by Architect approved equal, as part of tested and approved NFPA 285 compliant assembly:
   a. Master Builders Solutions (formerly BASF); Senershield VB or Enershield
   b. GCP Applied Technologies (formerly Grace Construction Products; W.R. Grace & Co. ); Perm-A-Barrier NPL

2. Physical and Performance Properties: Comparable products meeting the following requirements may be approved by the Architect for use on the Project:
   b. Air Permeance (Air Leakage), Material: Maximum 0.0001 cfm/sq. ft. of surface area at 1.57-lbf/sq. ft. (75 Pa) pressure difference; ASTM E 2178.
   c. Air-Barrier Assembly Air Leakage: Maximum 0.002 cfm/sq. ft. of surface area at 1.57 lb/sq. ft. (75 Pa) pressure difference; ASTM E 2357.
   d. Vapor Permeance: Maximum 0.1 perm; ASTM E 96/E 96M.
   e. Ultimate Elongation: Minimum 346 percent; ASTM D 412, Die C.
   f. In-Service Temperature: Not less than 180 deg F
   g. Adhesion: ASTM D4541; 16 psi on exterior sheathing.
   h. Nail Sealability: Pass; ASTM D 1970

3. Application: Use over exterior sheathing behind continuous insulation in the following locations:
   a. With composite support thermal spacer system in thin brick masonry applications.
   b. With composite support thermal spacer system in rainscreen metal wall panel cladding applications.
   c. In face brick veneer wall cavities.
2.4 SELF-ADHERED FLASHING MEMBRANE

A. Self-Adhered Flashing Membrane: Smooth surfaced, self-adhering composite membrane consisting of butyl-modified or rubberized asphalt adhesive laminated to a polyethylene-, polyolefin-, or polypropylene-film with release liner backing; specifically designed to withstand high temperatures beneath metal roofing, copings, flashings, and other non-roof detail areas. Provide primer according to written recommendations of underlayment manufacturer. Coordinate and ensure compatibility with, and adhesion to, adjacent materials.

1. Basis-of-Design Product: Subject to compliance with requirements, provide ExoAir 111 as manufactured by Tremco Inc., or comparable by the following, or by Architect approved equal, as compatible with primary air barrier membrane:
   b. GCP Applied Technologies (formerly Grace Construction Products; W.R. Grace & Co.).

2. Physical and Performance Properties:
   b. VOC: 0
   c. Air Permeance (Air Leakage), Material: Maximum 0.0001 cfm/sq. ft. of surface area at 1.57-lbf/sq. ft. (75 Pa) pressure difference; ASTM E 2178.
   d. Ultimate Elongation: Minimum 600 percent; ASTM D 412, Die C.
   f. Lap Adhesion: Minimum 2 lbf; ASTM D 1876.

3. Application: Use over exterior sheathing behind continuous insulation with plaster assemblies.

2.5 ACCESSORY MATERIALS

A. General: Accessory materials recommended by air-barrier manufacturer to produce a complete air-barrier assembly and compatible with primary air-barrier material.

B. Transition Membrane: Between Air Barrier Membrane and Other Adjacent Materials: Comply with both air barrier manufacturer’s recommendations and adjacent material manufacturer’s recommendations. Available products as follows as instructed by primary membrane manufacturer:

1. Liquid Flashing: Manufacturer’s standard trowel grade liquid flashing.

2. Butyl Strip: 30 to 40 mils thick, self-adhering; polyethylene-film-reinforced top surface laminated to layer of butyl adhesive with release liner backing.

3. Modified Bituminous Strip: 24 to 40 mils thick, self-adhering; polyethylene-film-reinforced top surface laminated to layer of rubberized asphalt adhesive with release liner backing.

4. High Temperature Modified Bituminous Strip: Refer to high temperature membrane specified above.
   a. For use under metal copings and flashings.

5. Foil Faced Modified Bituminous Strip: 40 mils thick, smooth surfaced, self-adhering flexible composite membrane flashing with an aluminum facer.


C. Primer: Liquid primer recommended for substrate by air-barrier material manufacturer.

D. Substrate-Patching Membrane: Manufacturer's standard trowel-grade substrate filler.

E. Adhesive and Tape: Air-barrier manufacturer's standard adhesive and pressure-sensitive adhesive tape.

F. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304, 0.0187 inch thick, and Series 300 stainless-steel fasteners.

G. Sprayed Polyurethane Foam Sealant: One- or two-component, foamed-in-place, polyurethane foam sealant, not more than 2.3-lb/cu. ft density; flame-spread index of 25 or less according to ASTM E 162; with primer and noncorrosive substrate cleaner recommended by foam sealant manufacturer.

H. Joint Sealant: ASTM C 920, single-component, neutral-curing silicone; Class 50, Grade NS, Use NT related to exposure, and, as applicable to joint substrates indicated, Use O. Comply with Section 079200 “Joint Sealants”. Sealant shall be approved for use with NFPA 285-compliant fire assembly.

I. Termination Mastic: Air-barrier manufacturer's standard cold fluid-applied elastomeric liquid; trowel grade.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

1. Verify that substrates are sound and free of oil, grease, dirt, excess mortar, or other contaminants.
2. Verify that concrete has cured and aged for minimum time period recommended by air-barrier manufacturer.
3. Verify sealants used in sheathing are compatible with membrane proposed for use. Perform field peel-adhesion test on materials to which sealants are adhered.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SURFACE PREPARATION

A. Clean, prepare, treat, and seal substrate according to manufacturer's written instructions. Provide clean, dust-free, and dry substrate for air-barrier application.

B. Mask off adjoining surfaces not covered by air barrier to prevent spillage and overspray affecting other construction.
C. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids in concrete with substrate-patching membrane.

D. At changes in substrate plane, apply sealant or termination mastic beads at sharp corners and edges to form a smooth transition from one plane to another.

E. Cover gaps in substrate plane and form a smooth transition from one substrate plane to another with stainless-steel sheet mechanically fastened to structural framing to provide continuous support for air barrier.

F. Bridge and cover discontinuous wall-to-wall, deck-to-wall, and deck-to-deck joints with overlapping transition membranes.

G. At changes in substrate plane, apply sealant or termination mastic beads at sharp corners and edges to form a smooth transition from one plane to another.

H. Cover gaps in substrate plane and form a smooth transition from one substrate plane to another with stainless-steel sheet mechanically fastened to structural framing to provide continuous support for air barrier.

3.3 JOINT TREATMENT

A. Gypsum Sheathing: Fill joints greater than 1/4 inch with sealant according to ASTM C 1193 and air-barrier manufacturer's written instructions. Apply first layer of fluid air-barrier material at joints. Tape joints with joint reinforcing strip after first layer is dry. Apply a second layer of fluid air-barrier material over joint reinforcing strip.

3.4 TRANSITION MEMBRANE INSTALLATION

A. General: Install transition membrane and accessory materials according to air-barrier manufacturer's written instructions to form a seal with adjacent construction and maintain a continuous air barrier.

   1. Coordinate the installation of air barrier with installation of roofing membrane, below grade waterproofing, and base flashing to ensure continuity of air barrier with roofing membrane.

   2. Install manufacturer's recommended transition strip on roofing membrane or base flashing so that a minimum of 3 inches of coverage is achieved over each substrate.

B. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by fluid air-barrier material on same day. Reprime areas exposed for more than 24 hours.

   1. Prime glass-fiber-surfaced gypsum sheathing with number of prime coats needed to achieve required bond, with adequate drying time between coats.

C. Connect and seal exterior wall air-barrier material continuously to roofing-membrane air barrier, concrete below-grade structures, floor-to-floor construction, exterior glazing and window systems, glazed curtain-wall systems, storefront systems, exterior louvers, exterior door framing, and other construction used in exterior wall openings, using accessory materials as recommended by manufacturer.

D. At end of each working day, seal top edge of transition membrane to substrate with termination mastic.
E. Apply joint sealants forming part of air-barrier assembly within manufacturer's recommended application temperature ranges. Consult manufacturer when sealant cannot be applied within these temperature ranges.

F. Wall Openings: Prime concealed, perimeter frame surfaces of windows, curtain walls, storefronts, and doors. Follow manufacturer's instructions and requirements of NFPA 285 for treatment of air-barrier membrane, transition membranes, and flashing at openings in exterior walls. Apply one of the following manufacturer instructed transition membranes so that a minimum of 3 inches of coverage is achieved over each substrate, unless otherwise indicated or required. Maintain 3 inches of full contact over firm bearing to perimeter frames with not less than 1 inch of full contact.
   1. Adhesive-Coated Transition Strip: Roll firmly to enhance adhesion.
   2. Elastomeric Flashing Sheet: Apply adhesive to wall, frame, and flashing sheet. Install flashing sheet and termination bars, fastened at 6 inches o.c. Apply lap sealant over exposed edges and on cavity side of flashing sheet.
   3. Preformed Silicone-Sealant Extrusion: Set in full bed of silicone sealant applied to walls, frame, and air-barrier material.

G. Fill gaps in perimeter frame surfaces of windows, curtain walls, storefronts, and doors, and miscellaneous penetrations of air-barrier material with foam sealant.

H. Seal transition membrane around masonry reinforcing or ties and penetrations with termination mastic.

I. Seal top of through-wall flashings to air barrier with an additional 6-inch-wide, transition membrane.

J. Seal exposed edges of transition membrane at seams, cuts, penetrations, and terminations not concealed by metal counterflashings or ending in reglets with termination mastic.

K. Repair punctures, voids, and deficient lapped seams in transition membrane. Slit and flatten fishmouths and blisters. Patch with transition strips extending 6 inches beyond repaired areas in strip direction.

3.5 FLUID AIR-BARRIER MEMBRANE INSTALLATION

A. General: Apply fluid air-barrier material to form a seal with transition membrane and to achieve a continuous air barrier according to air-barrier manufacturer's written instructions. Apply fluid air-barrier material within manufacturer's recommended application temperature ranges.
   1. Apply primer to substrates at required rate and allow it to dry.
   2. Limit priming to areas that will be covered by fluid air-barrier material on same day. Reprime areas exposed for more than 24 hours.
   3. Prime glass-fiber-surfaces gypsum sheathing with number of prime coats as recommended by the manufacturer and as needed to achieve required bond, with adequate drying time between coats.

B. Membrane Air Barriers: Apply a continuous unbroken air-barrier membrane to substrates according to the following thickness. Apply air-barrier membrane in full contact around protrusions such as masonry ties.
   1. Apply to a total wet film thickness as required by the membrane manufacturer to meet the performance requirements indicated.

C. Apply transition membrane according to air-barrier manufacturer's written instructions.
D. Provide air barrier and accessories that are acceptable for use at horizontal surfaces without detrimental effects to material.

E. Do not cover air barrier until it has been tested and inspected by District's testing agency.

F. Seal penetrations in fluid-applied air barrier watertight, including penetrations caused by fastening of rainscreen support system brackets and girts prior to installation of wall cladding.

G. Correct deficiencies in or remove air barrier that does not comply with requirements; repair substrates and reapply air-barrier components.

3.6 SELF-ADHERING SHEET AIR BARRIER INSTALLATION

A. General: Install modified bituminous sheets and accessory materials according to air-barrier manufacturer's written instructions and according to recommendations in ASTM D 6135.

1. When ambient and substrate temperatures, install self-adhering, modified bituminous air-barrier sheet produced for low-temperature application. Do not install low-temperature sheet if ambient or substrate temperature is higher than.

B. Corners: Prepare, prime, and treat inside and outside corners according to ASTM D 6135.

1. Install modified bituminous strips centered over vertical inside corners. Install 3/4-inch fillets of termination mastic on horizontal inside corners.

C. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations with termination mastic and according to ASTM D 6135.

D. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by air-barrier sheet on same day. Reprime areas exposed for more than 24 hours.

1. Prime glass-fiber-surfaced gypsum sheathing with number of prime coats needed to achieve required bond, with adequate drying time between coats.

E. Apply and firmly adhere modified bituminous sheets horizontally over area to receive air barrier. Accurately align sheets and maintain uniform 2-1/2-inch- (64-mm-) minimum lap widths and end laps. Overlap and seal seams, and stagger end laps to ensure airtight installation.

1. Apply sheets in a shingled manner to shed water without interception by any exposed sheet edges.
2. Roll sheets firmly to enhance adhesion to substrate.

F. Apply continuous modified bituminous sheets over modified bituminous strips bridging substrate cracks, construction, and contraction joints.

G. At end of each working day, seal top edge of air-barrier material to substrate with termination mastic.

H. Repair punctures, voids, and deficient lapped seams in air barrier. Slit and flatten fishmouths and blisters. Patch with air-barrier sheet extending 6 inches (150 mm) beyond repaired areas in all directions.

I. Apply transition membrane according to air-barrier manufacturer's written instructions.
J. For horizontal surfaces with slopes less than 1:12, use two layers of modified bituminous sheet. Stagger seams of first layer and second layer. Do not align seams of first ply with second ply. Apply sheets from low to high points of horizontal surface to ensure that laps shed water.

K. Do not cover air barrier until it has been tested and inspected by Owner's testing agency.

L. Correct deficiencies in or remove air barrier that does not comply with requirements; repair substrates and reapply air-barrier components.

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Inspections: Arrange for air barrier system manufacturer's technical personnel to inspect installation weekly during periods of ongoing installation, and at completion of air barrier application.

B. District's Inspection and Testing: Cooperate with District's testing agency. Allow access to work areas and staging. Notify District's testing agency in writing of schedule for Work of this Section to allow sufficient time for testing and inspection. Daily inspection and testing may be required. Do not cover Work of this Section until testing and inspection is accepted.

C. District will engage a qualified testing agency to perform the following tests:

1. Water-Spray Test: After installation, test area of installed assembly as directed by Architect for water penetration according to AAMA 501.2.
   a. Field Tests: Test separately and as a component of field-quality control tests required by other Sections, including, but not necessarily limited to, cement plastering, exterior metal-composite-material wall panels, face brick masonry, and thin brick masonry veneer.
   b. Require manufacturer's technical personnel to attend testing procedures.
   c. Where air barrier is used as a water-resistive barrier in rainscreen applications, test before and after installation of wall cladding support system installation but prior to wall cladding installation.

2. Air Barrier Adhesion Testing: Test for minimum air-barrier adhesion of 16 lbf/sq. in. or to manufacturer's minimum adhesion level per substrates, whichever is greater, according to ASTM D 4541 for each 600 sq. ft. of installed air barrier or part thereof for each substrate.

D. Inspections: Air-barrier materials, accessories, and installation shall be inspected for compliance with the following requirements.

1. Continuity of air-barrier system has been achieved throughout the building envelope with no gaps or holes.
2. Air-barrier wet and dry film thicknesses.
3. Continuous structural support of air-barrier system has been provided.
4. Site conditions for application temperature and dryness of substrates have been maintained.
5. Maximum exposure time of materials to UV deterioration has not been exceeded.
6. Surfaces have been primed, if applicable.
7. Laps in transition membranes have complied with minimum requirements and have been shingled in the correct direction (or mastic has been applied on exposed edges), with no fishmouths.
8. Termination mastic has been applied on cut edges.
9. Transition membranes are firmly adhered to substrate.
10. Compatible materials have been used.
11. Transitions at changes in direction and structural support at gaps have been provided.
12. Connections between assemblies (air-barrier and sealants) have complied with requirements for cleanliness, surface preparation and priming, structural support, integrity, and continuity of seal.

13. Penetrations have been sealed.


E. Air barriers will be considered defective if they do not pass tests and inspections.
   1. Apply additional air-barrier material, according to manufacturer's written instructions, where inspection results indicate insufficient thickness.
   2. Remove and replace deficient air-barrier components for retesting as specified above.
   3. Upon failure of testing:
      a. Repair and retest area.
      b. Provide an addition three tests for each occurrence of a failure.

F. Repair damage to air barriers caused by testing; follow manufacturer's written instructions.

3.8 CLEANING AND PROTECTION

A. Protect air-barrier system from damage during application and remainder of construction period, according to manufacturer's written instructions.
   1. Protect air barrier from exposure to UV light and harmful weather exposure as required by manufacturer. If exposed to these conditions for longer than allowed by manufacturer, remove and replace air barrier or install additional, full-thickness, air-barrier application after repairing and preparing the overexposed membrane according to air-barrier manufacturer's written instructions.
   2. Protect air barrier from contact with incompatible materials and sealants not approved by air-barrier manufacturer.

B. Clean spills, stains, and soiling from construction that would be exposed in the completed work using cleaning agents and procedures recommended by manufacturer of affected construction.

C. Remove masking materials after installation.

END OF SECTION
SECTION 074213 - METAL WALL PANELS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes metal composite material wall panel cladding system.

B. Related Requirements:
   1. Section 01030 "Alternates" for information effecting this Section.
   2. Section 061600 "Sheathing" for exterior wall sheathings and wall sheathing joint-and-penetration treatments.
   3. Section 072100 "Thermal Insulation" for insulation board and composite thermal spacer support system used as part of an approved NFPA 285 compliant wall assembly.
   4. Section 072726 "Membrane Air Barriers" for fluid-applied water-resistive air barrier used as part of an approved NFPA 285 compliant metal wall panel assembly.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Meet with District, Architect, District's insurer if applicable, metal composite material panel Installer, metal composite material panel manufacturer's representative, structural-support Installer, and installers whose work interfaces with or affects metal composite material panels, including installers of doors, windows, and louvers.
   2. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
   3. Review methods and procedures related to metal composite material panel installation, including manufacturer's written instructions.
   4. Examine support conditions for compliance with requirements, including alignment between and attachment to structural members.
   5. Review flashings, special siding details, wall penetrations, openings, and condition of other construction that affect metal composite material panels.
   6. Review governing regulations and requirements for insurance, certificates, and tests and inspections if applicable.
   7. Review temporary protection requirements for metal composite material panel assembly during and after installation.
   9. Document proceedings, including corrective measures and actions required, and furnish copy of record to each participant.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of panel and accessory.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings:
   1. Include fabrication and installation layouts of metal composite material panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment assembly, trim, flashings, closures, and accessories; and special details.

D. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below.
   1. Metal Composite Material Panels: 12 inches long by actual panel width. Include fasteners, closures, and other metal composite material panel accessories.

E. Delegated-Design Submittal: For glazed aluminum curtain walls indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Certification: Manufacturer's certificate of compliance with NFPA 285 for each component.

B. Test Reports: Test reports indicating approval of each product as part of an NFPA 285 compliant assembly.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Provide the following upon request:
   1. Qualification Data: For Installer.
   2. Product Test Reports: For each product, tests performed by a qualified testing agency.
   3. Field quality-control reports.

C. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
   1. Build mockup of typical metal composite material panel assembly as shown on Drawings, including corner, soffits, supports, attachments, and accessories.
   2. Include as part of standalone exterior envelope mockup.
   3. Water-Spray Test: Conduct water-spray test of mockup of metal composite material panel assembly, testing for water penetration according to AAMA 501.2.
   4. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver components, metal composite material panels, and other manufactured items so as not to be damaged or deformed. Package metal composite material panels for protection during transportation and handling.
B. Unload, store, and erect metal composite material panels in a manner to prevent bending, warping, twisting, and surface damage.

C. Stack metal composite material panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal composite material panels to ensure dryness, with positive slope for drainage of water. Do not store metal composite material panels in contact with other materials that might cause staining, denting, or other surface damage.

D. Retain strippable protective covering on metal composite material panels during installation.

1.8 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal composite material panels to be performed according to manufacturers' written instructions and warranty requirements.

1.9 COORDINATION

A. Coordinate metal composite material panel installation with rain drainage work, flashing, trim, construction of soffits, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal composite material panel systems that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures including rupturing, cracking, or puncturing.
   b. Deterioration of metals and other materials beyond normal weathering.

2. Warranty Period: Two years from date of Substantial Completion.

B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal composite material panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
   a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
   b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
   c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 FIRE PERFORMANCE REQUIREMENTS

A. Fire Propagation Characteristics: Where indicated, water-resistive air barriers and associated components shall have passed NFPA 285 testing as part of an approved assembly. Substitution of listed products, if approved by Architect as an equal, shall be with comparable products meeting same fire propagation requirements as a component in a listed assembly tested and approved by Underwriter Laboratories, Inc. or another third party testing agency acceptable to the governing authority. Engineering Judgments prepared by the manufacturer shall be preapproved by the authority having jurisdiction.

B. It is not the intention to preclude the use of other comparable products as approved by the Architect, as long as the product meets the criteria and complies with NFPA 285 as part of an approved assembly. Substitution requests shall include certification and technical data from the manufacturer indicating that the product has been tested and approved in a listed assembly. Components of an approved NFPA 285-compliant air-barrier assembly include the following:
   1. Metal Wall Panel Assembly: Water-resistive-barrier on exterior glass-mat-faced sheathing on metal studs, mineral-wool cavity insulation board, noncombustible subframing, aluminum panel wall cladding, similar or equal to Intertek Design No. RI/MFF 30-01.

C. Fire-Resistance Ratings: Comply with ASTM E 119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Indicate design designations from UL’s “Fire Resistance Directory” or from the listings of another qualified testing agency.

2.2 GENERAL PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide metal composite material panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E 330:
   1. Wind and Seismic Loads: As indicated on Drawings.
   2. Other Design Loads: As indicated on Drawings.
   3. Deflection Limits: For wind loads, no greater than 1/180 of the span.
   4. Preload at +12.5 pounds per square foot.

B. Air Infiltration: Air leakage of not more than 0.06 cfm/sq. ft. when tested according to ASTM E 283 at the following test-pressure difference:
   1. Test-Pressure Difference: 1.57 lbf/sq. ft.

C. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 331 at the following test-pressure difference:
   1. Test-Pressure Difference: 15 lbf/sq. ft.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
   1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.
2.3 METAL COMPOSITE MATERIAL WALL PANELS

A. Metal Composite Material Wall Panel Systems, General: Provide factory-formed and -assembled, metal composite material wall panels fabricated from two metal facings that are bonded to a solid, extruded thermoplastic core; formed into profile for installation method indicated. Include thermal spacer attachment assembly components, subframing, panel stiffeners, and accessories required for weathertight dry gasket sealed system.

1. Basis-of-Design Fabricators: Subject to compliance with requirements, provide Rout and Return Dry product system as manufactured by NOW Specialties, Inc, or comparable by one of the following listed system and fabricators for use in NFPA 285 compliant assembly.

B. Aluminum-Faced Composite Wall Panels: Formed with 0.020-inch- thick, coil-coated aluminum sheet facings.

1. Panel Products: Subject to compliance with requirements, provide one of the following panels for use in tested and approved NFPA 285 compliant system:
   a. Arconic (formerly Alcoa Architectural Products); Reynobond FR.
   b. Alcotex; Alcotex/FR.
   c. ALUCOBOND; 3A Composites USA, Inc.; Alucobond Plus.
   d. Mitsubishi Plastics Composites America, Inc.; Alpolic FR.

2. Panel Thickness: 4 mm.
3. Core: Fire retardant.
   a. Color: As selected by Architect from manufacturer's full range.

2.4 EXPOSED-FASTENER, LAP-SEAM METAL WALL PANELS

A. General: Provide factory-formed metal panels designed to be field assembled by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in sidelaps. Include accessories required for weathertight installation.

B. Alternates: Refer to Section 01030 "Alternates" for information effecting this Section.

C. Tapered-Rib-Profile, Exposed-Fastener Metal Wall Panels: Formed with raised, trapezoidal major ribs.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Model BR-28 as manufactured by Morin; a Kingspan Group company, or comparable product by one of the following:
   b. CENTRIA Architectural Systems.
   c. MBCI; a division of NCI Building Systems, L.P.

2. Aluminum Sheet: Coil-coated sheet, ASTM B 209, alloy as standard with manufacturer, with temper as required to suit forming operations and structural performance required.
   a. Thickness: 0.050 inch.
   b. Surface: Smooth, flat finish.
   d. Color: As selected by Architect from manufacturer's full range.
3. Major-Rib Spacing: Not less than 6 inches o.c.
5. Panel Height: 1.5 inches.
6. Sound-Absorbing Backing: K-Flex Duct Liner as manufactured by K-Flex, USA; 2 inch thick.

2.5 MISCELLANEOUS MATERIALS

A. Composite Support Framing System: Refer to Section 072100 "Thermal Insulation."

B. Weather-Resistive-Barrier (WRB): Fluid-applied air barrier complying with Section 072726 "Membrane Air Barriers" as part of NFPA 285 compliant assembly.

C. Continuous Rigid Insulation: Semi-rigid mineral wool board complying with Section 072100 "Thermal Insulation" as part of NFPA 285 compliant assembly.

D. Miscellaneous Metal Subframing and Furring: ASTM C 645, cold-formed, metallic-coated steel sheet ASTM A 653/A 653M, G90 coating designation or ASTM A 792/A 792M, Class AZ50 aluminum-zinc-alloy coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal composite material panel system.

E. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, copings, fasciae, Mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal composite material panels unless otherwise indicated.

F. Flashing and Trim: Provide flashing and trim formed from same material as metal composite material panels as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, bases, drips, sills, jambs, corners, endwalls, framed openings, rakes, fasciae, parapet caps, soffits, reveals, and fillers. Finish flashing and trim with same finish system as adjacent metal composite material panels.

G. Panel Fasteners: Self-tapping screws designed to withstand design loads. Provide exposed fasteners with heads matching color of metal composite material panels by means of plastic caps or factory-applied coating. Provide EPDM or PVC sealing washers for exposed fasteners.

H. Panel Sealants: ASTM C 920; elastomeric polyurethane or silicone sealant; of type, grade, class, and use classifications required to seal joints in metal composite material panels and remain weathertight; and as recommended in writing by metal composite material panel manufacturer.

2.6 FABRICATION

A. General: Fabricate and finish metal composite material panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

B. Fabricate metal composite material panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.
C. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

1. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.
3. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.
4. Sealed Joints: Form non-expansion, but movable, joints in metal to accommodate sealant and to comply with SMACNA standards.
5. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.
6. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended in writing by metal panel manufacturer.
   a. Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal wall panel manufacturer for application but not less than thickness of metal being secured.

2.7 FINISHES

A. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

C. Aluminum Panels and Accessories:

1. Three-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers’ written instructions.
2. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil (0.013 mm).

2.8 RAINSCREEN ATTACHMENT/THERMAL SPACER SUPPORT FRAMING SYSTEM

A. Basis of Design Product: Subject to compliance with requirements, provide Cascadia Clip as manufactured by Cascadia Windows Inc., or comparable by the following:

1. Advanced Architectural Products; Smartci Greengirt

B. Fire Propagation Characteristics: Attachment system shall be tested and approved as part of an NFPA 285 compliant assembly.

C. Sub-framing Thermal Spacer:

1. Noncombustible, glass fiber and thermoset polyester resin or glass fiber coated metal insulation clip.
2. Thermal spacer depth: 2 inches nominal.
   a. Depth tolerance: ± 0.005 inches.

D. Fasteners:
1. Sufficient length to provide solid attachment to structure as required by manufacturer
designed to withstand design loads.
2. Spacing and Embedment Depth: Comply with manufacturer's Professional Engineer's
project specific calculations.

E. Attachment Accessories:
1. Bracing, Furring, Bridging, Plates, and Clips: Formed sheet steel, thickness as necessary
to meet structural requirements for special conditions encountered.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with
requirements for installation tolerances, metal composite material panel supports, and other
conditions affecting performance of the Work.

1. Examine wall framing to verify that girts, angles, channels, studs, and other structural
panel support members and anchorages have been installed within alignment tolerances
required by metal composite material wall panel manufacturer.
2. Examine wall sheathing to verify that sheathing joints are supported by framing or
blocking and that installation is within flatness tolerances required by metal composite
material wall panel manufacturer.
   a. Verify that air- or water-resistant barriers have been installed over sheathing or
backing substrate to prevent air infiltration or water penetration.

B. Examine roughing-in for components and assemblies penetrating metal composite material
panels to verify actual locations of penetrations relative to seam locations of metal composite
material panels before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Miscellaneous Supports: Install subframing, furring, thermal spacers, and other miscellaneous
panel support members and anchorages according to ASTM C 754 and metal composite
material panel manufacturer's written recommendations.

B. Sub-framing Thermal Spacer Installation: Install thermal spacers in accordance with spacer
manufacturer's written recommendations.
1. Completely install spacers, screws and sub-framing, and perform field-quality control
water spray test prior to installation of insulation.
   a. Once installation of thermal spacers has been tested and approved by metal panel
manufacturer, friction fit insulation in place before completing installation of z-girt
panel supports.
b. Ensure insulation is tightly fitted with sides of insulation slightly compressed at each insulation spacer. Ensure insulation pieces are in contact with no linear gaps between spacers.

2. Attach z-girts panel supports to thermal spacers.

3. METAL COMPOSITE MATERIAL PANEL INSTALLATION

A. General: Install metal composite material panels according to manufacturer's written instructions in orientation, sizes, and locations indicated on Drawings. Install panels perpendicular to supports unless otherwise indicated. Anchor metal composite material panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Shim or otherwise plumb substrates receiving metal composite material panels.
2. Flash and seal metal composite material panels at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until air- or water-resistive barriers and flashings that will be concealed by metal composite material panels are installed.
3. Install screw fasteners in predrilled holes.
4. Locate and space fastenings in uniform vertical and horizontal alignment.
5. Install flashing and trim as metal composite material panel work proceeds.
6. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.
7. Align bottoms of metal composite material panels and fasten with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.
8. Provide weathertight escutcheons for pipe- and conduit-penetrating panels.

B. Fasteners:

1. Aluminum Panels: Use aluminum or stainless-steel fasteners for surfaces exposed to the exterior; use aluminum or galvanized-steel fasteners for surfaces exposed to the interior.

C. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action as recommended in writing by metal composite material panel manufacturer.

D. Attachment Assembly, General: Install attachment assembly required to support metal composite material wall panels and to provide a complete weathertight wall system, including subgirts, perimeter extrusions, tracks, drainage channels, panel clips, and anchor channels.

1. Include attachment to supports, panel-to-panel joinery, panel-to-dissimilar-material joinery, and panel-system joint seals.
2. Install wall panels to allow individual panels to be installed and removed without disturbing adjacent panels.
3. Ensure horizontal members have pre-formed or pre-drilled weep holes for drainage.

E. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal composite material panel assembly including trim, coping, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items. Provide types indicated by metal composite material panel manufacturer; or, if not indicated, provide types recommended in writing by metal composite material panel manufacturer.
3.4 ERECTION TOLERANCES

A. Installation Tolerances: Shim and align metal composite material wall panel units within installed tolerance of 1/4 inch in 20 feet, non-accumulative, on level, plumb, and location lines as indicated, and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: a qualified independent testing agency to perform field tests and inspections.

B. Water-Spray Test: Test area of assembly as directed by Architect for water penetration according to AAMA 501.2. Test assembly after installation of composite support system but prior to installation of wall panel in accordance with Section 072726 "Membrane Air Barriers." Testing of assembly after wall panel installation is not required.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect completed metal composite material wall panel installation, including accessories.

D. Metal composite material wall panels will be considered defective if they do not pass test and inspections.

E. Additional tests and inspections, at Contractor's expense, are performed to determine compliance of replaced or additional work with specified requirements.

F. Prepare test and inspection reports.

3.6 CLEANING AND PROTECTION

A. Remove temporary protective coverings and strippable films, if any, as metal composite material panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal composite material panel installation, clean finished surfaces as recommended by metal composite material panel manufacturer. Maintain in a clean condition during construction.

B. After metal composite material panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.

C. Replace metal composite material panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION
SECTION 075419 - POLYVINYL-CHLORIDE (PVC) ROOFING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

   A. Section Includes:
      1. Mechanically-attached PVC membrane roofing system.
      2. Vapor retarder.
      3. Roof insulation.

   B. Related Requirements:
      1. Division 06 Section "Rough Carpentry " for wood nailers, curbs, and blocking.
      2. Division 07 Section "Sheet Metal Flashing and Trim" for metal roof penetration flashings, flashings, and counter-flashings.
      3. Division 07 Section "Joint Sealants" for joint sealants, joint fillers, and joint preparation.

1.3 DEFINITIONS

   A. Roofing Terminology:  See ASTM D 1079 and glossary in NRCA's "The NRCA Roofing and Waterproofing Manual" for definition of terms related to roofing work in this Section.

1.4 ACTION SUBMITTALS

   A. Product Data:  For each type of product indicated.

   B. LEED Submittals in accordance with Section 018113 "Sustainable Design Requirements" applicable to this Section.

   C. Shop Drawings: For roofing system. Include plans, elevations, sections, project specific details, and attachments to other work.
      1. Base flashings and membrane terminations.
      2. Tapered insulation, including slopes.
      3. Roof plan showing orientation of steel roof deck and orientation of membrane roofing, fastening spacings and patterns for mechanically fastened membrane roofing.
      4. Insulation fastening patterns for corner, perimeter, and field-of-roof locations.

   D. Samples for Verification:  For the following products:
      1. Sheet roofing, of color specified, including T-shaped side and end lap seam.
      2. Roof insulation.
      3. Metal termination bars.
1.5 INFORMATIONAL SUBMITTALS

A. Research/Evaluation Reports: For components of membrane roofing system, from the ICC-ES.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For roofing system to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer that is UL listed for membrane roofing system identical to that used for this Project.

B. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by membrane roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.

C. Source Limitations: Obtain components including roof insulation fasteners for membrane roofing system as approved by membrane roofing manufacturer and testing.

D. Exterior Fire-Test Exposure: ASTM E 108, Class A; for application and roof slopes indicated, as determined by testing identical membrane roofing materials by a qualified testing agency. Materials shall be identified with appropriate markings of applicable testing agency.

E. Fire-Resistance Ratings: Where indicated, provide fire-resistance-rated roof assemblies identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

F. Preliminary Roofing Conference: Before starting roof deck construction, conduct conference at Project site.

1. Meet with Owner, Architect, Owner's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, deck Installer, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.

2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.

3. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.

4. Review deck substrate requirements for conditions and finishes, including flatness and fastening.

5. Review structural loading limitations of roof deck during and after roofing.

6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that will affect roofing system.

7. Review governing regulations and requirements for insurance and certificates if applicable.

8. Review temporary protection requirements for roofing system during and after installation.

9. Review roof observation and repair procedures after roofing installation.

G. Pre-installation Roofing Conference: Conduct conference at Project site.
1. Meet with Owner, Architect, Owner’s insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer’s representative, deck Installer, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.

2. Review methods and procedures related to roofing installation, including manufacturer’s written instructions.

3. Review and finalize construction schedule and verify availability of materials, Installer’s personnel, equipment, and facilities needed to make progress and avoid delays.

4. Examine deck substrate conditions and finishes for compliance with requirements, including flatness and fastening.

5. Review structural loading limitations of roof deck during and after roofing.

6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that will affect roofing system.

7. Review governing regulations and requirements for insurance and certificates if applicable.

8. Review temporary protection requirements for roofing system during and after installation.

9. Review roof observation and repair procedures after roofing installation.

H. Provide the following upon request:

1. Qualification Data: For qualified Installer and manufacturer.

2. Manufacturer Certificates: Signed by roofing manufacturer certifying that roofing system complies with requirements specified in "Performance Requirements" Article.
   a. Submit evidence of compliance with performance requirements.

3. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for components of membrane roofing system.

4. Field quality-control reports.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer’s name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.

B. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.
   1. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.

C. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer’s written instructions for handling, storing, and protecting during installation.

D. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.
1.9 PROJECT CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.

1.10 WARRANTY

A. Special Manufacturer System Warranty: Manufacturer's standard or customized form, without monetary limitation, in which manufacturer agrees to repair or replace components of membrane roofing system that fail in materials or workmanship within specified warranty period.
   1. Special warranty includes membrane roofing, roof insulation, and roofing accessories provided by roofing manufacturer, including but not necessarily limited to base flashings, fasteners, adhesive and other components of membrane roofing system.
   2. Warranty Period: 20 years from date of Substantial Completion.

B. Special Project Warranty: Submit roofing Installer's warranty, on warranty form at end of this Section, signed by Installer, covering the Work of this Section, including all components of membrane roofing system including, but not necessarily limited to, membrane roofing, base flashings and roof-related sheet metal work, roof insulation, fasteners, adhesives, seals and sealants, cover boards, nailers, canters and blocking, and walkway products, for the following warranty period:
   1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Installed membrane roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Membrane roofing and base flashings shall remain watertight.

B. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by membrane roofing manufacturer based on testing and field experience.

C. Roofing System Design: Provide membrane roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE/SEI 7 and the following criteria.
   1. Wind Speed: Refer to drawings.
   2. Exposure Condition: Refer to drawings.
   3. Importance Factor: Refer to drawings.

D. Solar Reflectance Index (SRI): Not less than 78 after 3 years when calculated according to ASTM E 1980, based on testing identical products by a qualified testing agency.

E. Energy Performance: Provide roofing system with initial solar reflectance not less than 0.70 and emissivity not less than 0.85 when tested according to CRRC-1.
2.2 PVC MEMBRANE ROOFING

A. PVC Sheet: ASTM D 4434, Type III, PVC membrane containing ultraviolet light stabilizers, flame retardant, with heat weldable seams, and polyester scrim reinforcement with a unique lacquer coating on the top surface.

1. Products: Subject to compliance with requirements, provide the following, or Architect approved equal by one of the other listed manufacturers:
   a. Sika Corporation; Sarnafil S327EnergySmart Roof Membrane.

2. Overall Thickness: 60 mils, minimum.

3. Exposed Face Color: Tan, initial solar reflectance of 0.73, emittance of 0.85, and solar reflective index (SRI) of 89.

4. Breaking Strength: ASTM D 751, not less than 305 lbf.

5. Tearing Resistance: ASTM D 1004, not less than 48 lbf.

6. Other Manufacturers: Subject to compliance with requirements, other available manufacturers offering similar products that may be incorporated into the Work include, the following:
   a. GAF Materials Corporation.
   b. Johns Manville.

2.3 AUXILIARY MEMBRANE ROOFING MATERIALS

A. General: Auxiliary membrane roofing materials recommended by roofing system manufacturer for intended use, and compatible with membrane roofing.

1. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.

B. Attachment Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening membrane to substrate, and acceptable to membrane roofing system manufacturer.

1. Concrete Deck: Sarnafil Sarnafastener-CD1

C. Membrane Attachment Component: Sarnafil Sarnadisc-XP or Sarnadisc-MAXLoad, unless otherwise indicated or required by manufacturer to meet performance requirements.

D. Sheet Flashing: Manufacturer's standard sheet flashing of same material, type, reinforcement, thickness, and color as PVC sheet membrane.

E. Bonding Adhesive: Manufacturer's standard water-based adhesive.

F. Slip Sheet: Manufacturer's standard, of thickness required for application.

G. Metal Termination Bars: Manufacturer's standard, predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 inch thick; with anchors.

H. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, T-joint covers, lap sealants, termination reglets, and other accessories.

I. Reinforced Fluid Applied Flashing:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Soprema; Alsan RS 230 Flash system.

2.4 VAPOR RETARDER

A. New Concrete Roof Deck Application:
   1. SBS Modified Bitumen: Basis of Design: Soprema; Sopralene 180 SP 3.5, torch-applied. Primer required.
   2. 2-ply Built-up Asphalt Roof:
      b. Roofing Asphalt: ASTM D 312, Type III or Type IV.

2.5 ROOF INSULATION

A. General: Preformed roof insulation boards manufactured or approved by PVC membrane roofing manufacturer, of thicknesses indicated and that produce FM Approvals-approved roof insulation.

B. (PI-1) Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 2, Grade 2, coated glass-fiber mat facer on both major surfaces.
   1. Board Size: 4'-0" by 4'-0"
   2. Thickness: Two layers minimum, of total thickness required to provide a minimum aged thermal resistance of R30 (deg. F.h.sf/Btu).

C. Tapered Insulation: ASTM C 1289, Type II, Class 2, Grade 2, coated glass-fiber mat facer on both major surfaces. Provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches unless otherwise indicated.

D. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated. ASTM C 1289, Type II, Class 2, Grade 2, coated glass-fiber mat facer on both major surfaces.

2.6 INSULATION ACCESSORIES

A. General: Furnish roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with membrane roofing.

B. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation and cover boards to substrate, and acceptable to roofing system manufacturer.

C. Bead-Applied Insulation Adhesive: Insulation manufacturer's recommended bead-applied, low-rise, one- or multi-component urethane adhesive formulated to attach roof insulation to substrate or to another insulation layer.

D. Cover Board: ASTM C 1177 C 1177M factory-primed glass-mat-faced gypsum sheathing, or ASTM C 1278 homogeneous fiber-reinforced gypsum sheathing, 1/4 inch thick, minimum.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Georgia-Pacific Corporation; Dens Deck Prime Prime Roof Board.
      b. USG Corporation; Securock Brand Gypsum Fiber Roof Board.
2. Mold Resistance: Score of 10 as rated according to ASTM D 3273.

2.7 ASPHALT MATERIALS
   A. Roofing Asphalt: ASTM D 312, Type III or Type IV.
   B. Asphalt Primer: ASTM D 41.

2.8 WALKWAYS
   A. Flexible Walkways: Factory-formed, nonporous, heavy-duty, slip-resisting, surface-textured walkway pads or rolls, approximately 3/16 inch thick, and acceptable to membrane roofing system manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine substrates, areas, and conditions, with Installer present, for compliance with the following requirements and other conditions affecting performance of roofing system:
      1. Verify that roof openings and penetrations are in place and curbs are set and braced and that roof drain bodies are securely clamped in place.
      2. Verify that wood blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
      3. Verify that concrete has cured and aged for minimum time period required in writing by roofing manufacturer. Perform testing as required by roofing manufacturer for test type, rate, and quantity to validate that substrate is acceptable, dry, and free of moisture.
      4. Verify that concrete curing compounds that will impair adhesion of roofing components to roof deck have been removed.
   B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION
   A. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.
   B. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.
   C. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at the end of the workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing.
3.3 **VAPOR-RETARDER INSTALLATION**

A. New Concrete Roof Deck Application:
   1. **SBS Modified Bitumen**: Torch apply 1 ply of SBS modified bitumen vapor retarder according to manufacturer’s written instructions and applicable recommendations in ARMA/NRCA’s “Quality Control Guidelines for the Application of Polymer Modified Bitumen Roofing.”
   2. **Built-up Vapor Retarder**:
      a. Prime surface of concrete deck with asphalt primer at rate of 3/4 gal./100 sq. ft. or as required by manufacturer and allow primer to dry.
      b. Install two glass-fiber felt plies lapping each felt 19 inches over preceding felt.
      c. Embed each felt in a solid mopping of hot roofing asphalt.
      d. Glaze coat completed surface with hot roofing asphalt.
      e. Apply hot roofing asphalt within plus or minus 25 deg F of equiviscous temperature.

B. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into membrane roofing system.

C. Provide an air tight transition to the wall air barrier.

3.4 **INSULATION INSTALLATION**

A. Coordinate installing membrane roofing system components so insulation is not exposed to precipitation or left exposed at the end of the workday.

B. Comply with membrane roofing system and insulation manufacturer’s written instructions for installing roof insulation.

C. Install tapered insulation under area of roofing to conform to slopes indicated.

D. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches in each direction.

E. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.

F. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch with insulation.
   1. Cut and fit insulation within 1/4 inch of nailers, projections, and penetrations.

G. Mechanically Fastened and Adhered Insulation: Install each layer of insulation and secure first layer of insulation to deck using mechanical fasteners specifically designed and sized for fastening specified board-type roof insulation to deck type.
   1. Fasten first layer of insulation according to requirements in FM Approvals’ "RoofNav” for specified Windstorm Resistance Classification.
   2. Fasten first layer of insulation to resist uplift pressure at corners, perimeter, and field of roof.
   3. Set each subsequent layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
H. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches in each direction. Loosely butt cover boards together and fasten through insulation to roof deck.

1. Set cover board in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining cover board in place.

3.5 MECHANICALLY FASTENED MEMBRANE ROOFING INSTALLATION

A. Mechanically fasten membrane roofing over area to receive roofing and install according to roofing system manufacturer's written instructions.

1. Install sheet according to ASTM D 5082.
2. For in-splice attachment, install membranes roofing with long dimension perpendicular to steel roof deck flutes.

B. Start installation of membrane roofing in presence of roofing system manufacturer's technical personnel.

C. Accurately align membrane roofing and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.

D. Mechanically fasten membrane roofing securely at terminations, penetrations, and perimeter of roofing.

E. Apply membrane roofing with side laps shingled with slope of roof deck where possible.

F. Seams: Clean seam areas, overlap membrane roofing, and hot-air weld side and end laps of membrane roofing and sheet flashings according to manufacturer's written instructions to ensure a watertight seam installation.

1. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of sheet membrane.
2. Verify field strength of seams a minimum of twice daily and repair seam sample areas.
3. Repair tears, voids, and lapped seams in roofing that does not comply with requirements.

G. Spread sealant bed over deck drain flange at roof drains and securely seal membrane roofing in place with clamping ring.

H. Install membrane roofing and auxiliary materials to tie in to existing roofing to maintain weather-tightness of transition.

3.6 BASE FLASHING INSTALLATION

A. Install sheet flashings and preformed flashing accessories and adhere to substrates according to membrane roofing system manufacturer's written instructions.

B. Apply bonding adhesive to substrate and underside of sheet flashing at required rate and allow to partially dry. Do not apply to seam area of flashing.

C. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.

D. Clean seam areas, overlap, and firmly roll sheet flashings into the adhesive. Hot-air weld side and end laps to ensure a watertight seam installation.
E. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars.

3.7 WALKWAY INSTALLATION

A. Flexible Walkways: Install walkway products in locations indicated. Heat weld to substrate or adhere walkway products to substrate with compatible adhesive according to roofing system manufacturer's written instructions.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.

C. Repair or remove and replace components of membrane roofing system where inspections indicate that they do not comply with specified requirements.

D. Additional inspections, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.9 PROTECTING AND CLEANING

A. Protect membrane roofing system from damage and wear during remainder of construction period. When remaining construction will not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to Architect and Owner.

B. Correct deficiencies in or remove membrane roofing system that does not comply with requirements; repair substrates; and repair or reinstall membrane roofing system to a condition free of damage and deterioration at time of Substantial Completion and according to warranty requirements.

C. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION

Roof System Special Warranty Form follows.
ROOF SYSTEM SPECIAL PROJECT WARRANTY FORM

Project Title: Contra Costa College New Science Building
Owner: Contra Costa Community College District
Architect's Project No. 10418.000
Contractor's Job Number: ___________

Specification Section No. and Title: Section 075419 - Polyvinyl-Chloride (PVC) Roofing.
Warranted Work: Entire low-slope PVC roofing system.

Warranty shall cover the Work of this Section, including all components of membrane roofing system including, but not necessarily limited to, membrane roofing, base flashings and roof-related sheet metal work, roof insulation, fasteners, adhesives, seals and sealants, cover boards, nailers, cants, and blocking, and walkway products.

Length of Warranty: Two (2) years from date of Substantial Completion.

The undersigned herewith warrant that the above stated Work has been executed in conformance with the requirements of the Contract Documents for the Project named and warrant said Work to perform as specified and without failure for the above stated period of time, starting on ________, 20__, and ending on ________, 20___. This warranty does not apply to failure to perform due to abuse or neglect by the Owner, or the Owner's successor in interest, or damage by vandalism.

Contractor
Firm
Representative*
Signed
Title
Notary
Date

Roofing Installer
Firm
Representative*
Signed
Title
Notary
Date

[ ] Same as Contractor
If same as Contractor, check box; leave lines blank

Roofing System Manufacturer
Firm
Representative*
Signed
Title
Notary
Date

*The Firm's Representative affirms they are authorized to bind the Firm to this Warranty.

END OF SPECIAL PROJECT WARRANTY FORM
SECTION 075556 - FLUID-APPLIED PROTECTED MEMBRANE ROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Reinforced, hot fluid-applied protected membrane roof waterproofing.
3. Insulation.
4. Pavers supported on pedestals.
5. Electric field vector mapping (EFVM)

B. Related Requirements:
1. Section 01030 "Alternates" for information effecting this Section.
2. Section 076200 "Sheet Metal Flashing and Trim" for metal roof flashings and counterflashings.
3. Section 075423 "Thermoplastic Polyolefin (TPO) Roofing" for transition to single-ply membrane roofing.
4. Section 079200 "Joint Sealants" for joint sealants, joint fillers, and joint preparation.
5. Division 22 "Storm Drainage Piping Specialties" for roof drains.

1.2 DEFINITIONS

A. Roofing Terminology: See ASTM D 1079 and glossary of NRCA's "The NRCA Roofing and Waterproofing Manual" for definition of terms related to roofing work in this Section.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Roofing Conference: Conduct conference at Project site.
1. Meet with District, Architect, District's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.
2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
3. Review and finalize construction schedule, and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review substrate requirements for conditions and finishes, including flatness.
5. Review structural loading limitations of roof deck during and after roofing.
6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that affects roofing system.
7. Review governing regulations and requirements for insurance and certificates if applicable.
8. Review temporary protection requirements for roofing during and after installation.
9. Review roof observation and repair procedures after roofing installation.
1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work.
   1. Base flashings and membrane terminations.
   2. Tapered insulation, including slopes.
   3. Crickets, saddles, and tapered edge strips, including slopes.

D. Samples for Verification: For the following products:
   1. Roof insulation.
   2. Roof paver and pedestal, full sized, in each color and texture required.

1.5 INFORMATIONAL SUBMITTALS

A. Research/Evaluation Reports: For components of membrane roofing system, from the ICC-ES.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For roofing system to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer that is UL listed for membrane roofing system identical to that used for this Project.

B. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by membrane roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.

C. Source Limitations: Obtain components including roof insulation and fasteners for membrane roofing system from same manufacturer as membrane roofing or approved by membrane roofing manufacturer.

D. Exterior Fire-Test Exposure: ASTM E 108, Class A; for application and roof slopes indicated, as determined by testing identical membrane roofing materials by a qualified testing agency. Materials shall be identified with appropriate markings of applicable testing agency.

E. Fire-Resistance Ratings: Where indicated, provide fire-resistance-rated roof assemblies identical to those of assemblies tested for fire resistance per ASTM E 119 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

F. Mockups: Install roofing on 100 sq. ft. of deck to demonstrate surface preparation, joint and crack treatment, thickness of roofing, and execution quality. Install insulation and roof pavers over roofing membrane.
   1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
G. Provide the following upon request:

1. Qualification Data: For qualified installer and manufacturer.
2. Manufacturer Certificates: Signed by roofing manufacturer certifying that roofing system complies with requirements specified in "Performance Requirements" Article.
   a. Submit evidence of compliance with performance requirements.
3. Product Test Reports: Based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency, for components of membrane roofing system.
4. Field quality control reports.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.

B. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing manufacturer. Protect stored liquid material from direct sunlight.
   1. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.

C. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.

D. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.

1.9 PROJECT CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of roofing system that fail in materials or workmanship within specified warranty period.
   1. Warranty includes fluid-applied protected membrane roofing, base flashings, roof insulation, protection boards, drainage panels, filter fabric, fasteners and adhesive, and other components of protected membrane roofing system.
   2. Warranty Period: 15 years from date of Substantial Completion.

B. Special Project Warranty: Submit roofing Installer's warranty, on warranty form at end of this Section, signed by Installer, covering Work of this Section, including all components of fluid-applied protected membrane roofing system such as roofing membrane, base flashings, roof insulation, protection boards, drainage panels, filter fabric, pavers and pedestals, fasteners and adhesive, and other components of protected membrane roofing system for the following warranty period:
1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain roofing materials, sheet flashings, drainage sheets, protection sheets, and auxiliary materials from single source from the primary membrane manufacturer to ensure total system compatibility and integrity.

2.2 PERFORMANCE REQUIREMENTS

A. General Performance: Installed roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Roofing and base flashings shall remain watertight.

1. Accelerated Weathering: Roofing system shall withstand 2000 hours of exposure when tested according to ASTM G 152, ASTM G 154, or ASTM G 155.

2. Impact Resistance: Roofing system shall resist impact damage when tested according to ASTM D 3746 or ASTM D 4272.

B. Material Compatibility: Roofing materials shall be compatible with one another and adjacent materials under conditions of service and application required, as demonstrated by roofing manufacturer based on testing and field experience.

C. Roofing System Design: Provide membrane roofing system that is identical to systems that have been successfully tested by a qualified testing and inspecting agency to resist uplift pressure calculated according to ASCE/SEI 7.

D. Energy Performance: Roofing system shall have an initial solar reflectance not less than 0.70 and an emissivity of not less than 0.75 when tested according to CRRC-1.

E. Exterior Fire-Test Exposure: ASTM E 108 or UL 790, Class A; for application and roof slopes indicated; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

2.3 ROOFING MEMBRANE

A. Hot Fluid-Applied, Rubberized-Asphalt Roofing Membrane: Single component; 100 percent solids; hot fluid-applied, rubberized asphalt.

1. Basis-of-Design Product: Subject to compliance with requirements, provide American Hydrotech, Inc.; Monolithic Membrane 6125, or a comparable product by one of the following:

   a. Carlisle Coatings & Waterproofing Inc.
   b. CETCO, a Minerals Technologies company.
   c. Tremco Incorporated.

2. Recycled Content: Not less than 40 percent post-consumer.

3. Water Vapor Permeability: ASTM E-96, Procedure E; 0.027 perms

4. Elongation: ASTM D 5329; 1000 percent
6. Thickness: Total, including reinforcing: 215 mils

2.4 BASE FLASHING SHEET MATERIALS

A. Elastomeric Flashing Sheet: 60-mil-thick, minimum, uncured sheet neoprene with manufacturer's recommended contact adhesives as follows:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following, or Architect approved equal by listed manufacturer.
      a. American Hydrotech, Inc., Flex Flash UN

2.5 AUXILIARY ROOFING MEMBRANE MATERIALS

A. General: Auxiliary materials recommended by roofing manufacturer for intended use and compatible with roofing membrane.
   1. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.
   2. Recycle Content: Minimum 40 percent.

B. Surface Conditioner: Asphaltic surface conditioner for concrete surfaces.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following, or Architect approved equal by listed manufacturer.
      a. American Hydrotech, Inc., Surface Conditioner

C. Metal Termination Bars: Manufacturer's standard, predrilled, stainless-steel or aluminum termination bars, approximately 1 by 1/8 inch thick; with stainless-steel anchors.

D. Reinforcing Fabric: Manufacturer's standard duty, spun-bonded polyester fabric
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following, or Architect approved equal by listed manufacturer.
      a. American Hydrotech, Inc.; Flex Flash F.

2.6 SEPARATION/PROTECTION COURSE

A. Separation Sheet/Protection Course: Manufacturer's standard, specially formulated heavy duty, modified-asphalt protection sheet with synthetic fiber reinforcement.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following, or Architect approved equal by listed manufacturer:
   2. Thickness: 85 mils

2.7 MOLDED-SHEET DRAINAGE PANELS

A. Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel: Composite drainage system consisting of a three-dimensional, crush-proof, drainage core and a filter fabric meeting the following physical properties.
1. Basis-of-Design Product: Subject to compliance with requirements, provide the following, or Architect approved equal by listed manufacturer:
   a. American Hydrotech, Inc; Hydrodrain 1000.

2. Thickness: 0.25 inch
3. Compressive Strength: ASTM D 1621; 40,000 psf
4. Flow: ASTM D 4716; 8.5 gal/min/ft.

2.8 ROOF INSULATION

A. General: Preformed roof insulation boards manufactured or approved by roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated.

B. Extruded-Polystyrene Board Insulation, Type XPS-4: ASTM C 578, Type VII, unfaced; fabricated with shiplap or channel edges and with one face having grooved drainage channels; thickness and width indicated, and manufacturer's standard length as required to suit job conditions.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. DiversiFoam Products.
   b. Kingspan Greenguard.

2. Minimum compressive strength: ASTM D 1621, 60 psi
3. Minimum R-Value: 5.0 per inch

C. Adhesive for Bonding Insulation: Product with demonstrated capability to bond insulation securely to substrates without damaging insulation and substrates.

2.9 INSULATION ACCESSORIES

A. General: Roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with membrane roofing.

B. Protection Mat/Filter Fabric: Woven or nonwoven polymeric fabric, water permeable and resistant to UV degradation, type and weight as recommended by roofing system manufacturer for application.

2.10 ROOF PAVERS

A. Roof Pavers:Heavyweight, hydraulically pressed, concrete units, [square edged], factory cast for use as roof pavers; absorption not greater than 5 percent, ASTM C 140; no breakage and maximum 1 percent mass loss when tested for freeze-thaw resistance, ASTM C 67; and as follows:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following as selected by Architect:
   a. American Hydrotech, Inc., Architectural Pavers
   b. Hanover Architectural Products.
   c. Wausau Tile Inc.
   d. Hastings Pavement Company, LLC.
   e. Roofblok Limited.
f. Sunny Brook Pressed Concrete Co.

2. Thickness: Not less than 1-3/4 inches.
3. Size: 24 by 24 inches as selected by Architect. Manufacture pavers to dimensional tolerances of plus or minus 1/16 inch in length, height, and thickness.
4. Compressive Strength: 8500 psi, minimum; ASTM C 140.
5. Colors and Textures: As selected by Architect from manufacturer's full range.

B. Paver Supports/Pedestals: High-density polypropylene paver support assembly, including adjustable pedestals, shims, and spacer tabs for joint spacing of 3/16 inch.

1. Manufacturers: Subject to compliance with requirements, provide the following, or Architect approved equal by paver manufacturer:
   a. Bison Innovative Products; Model #LC-316.
2. Adjustable Range: 2-inch to 4-3/4-inch
3. Couplers: Adjustable up to 4-inches
4. Shims: 1/16-inch flexible and 1/8-inch rigid as required.
5. Base Leveler: Bison #LD4
6. Floating Insulation Base: Bison #FIB; 12- by 12-inch

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work:

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 JOINTS, CRACKS, AND TERMINATIONS

A. Prepare and treat substrates to receive roofing, including joints and cracks, roof drains, and penetrations, according roofing system manufacturer’s written instructions.

3.3 BASE FLASHING INSTALLATION

A. Install base flashing at terminations of roofing according to manufacturer's written instructions.

B. Bond elastomeric flashing sheet in contact adhesive against wall substrate to within 3 inches of deck. Adhere remaining vertical leg and horizontal leg of flashing sheet in a layer of hot fluid-applied, rubberized asphalt.

C. Extend flashing sheet up walls or parapets a minimum of 8 inches above insulation and 6 inches onto roof deck.

D. Install termination bars and mechanically fasten to top of flashing sheet at terminations and perimeter of roofing.
3.4 ROOFING MEMBRANE APPLICATION

A. Apply surface conditioner, at manufacturer's recommended rate, over prepared substrate and allow to dry.

B. Heat and apply rubberized asphalt according to manufacturer's written instructions.

C. Start application with manufacturer's authorized representative present.

D. Reinforced Membrane: Apply hot fluid-applied, rubberized asphalt to area to receive roofing. Spread a 90-mil-thick layer of hot fluid-applied, rubberized asphalt; embed reinforcing fabric, overlapping sheets 2 inches; spread another 125-mil-thick layer of hot fluid-applied, rubberized asphalt to form a uniform, reinforced, seamless membrane, 215 mils thick.

E. Cover membrane with protection course with overlapped joints before membrane is subject to construction traffic.

F. Loosely lay molded-sheet drainage panel over separation/protection course in accordance with manufacturer's instructions.

3.5 INSULATION INSTALLATION

A. Loosely lay board insulation units over drainage panel and roofing membrane, with drainage channels of insulation in continuous straight lines in the direction of slope to allow drainage and with end joints staggered between rows. Abut edges and ends between units.


3.6 ROOF-PAVER INSTALLATION

A. Install roof pavers on pedestals set according to pedestal manufacturer's written instructions.

B. Secure corners and perimeter with metal straps or other devices as instructed by paver manufacturer.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: District will engage a qualified testing agency to inspect substrate conditions, surface preparation, membrane application, flashings, protection, and drainage components, and to furnish reports to Architect.

1. Electric Field Vector Mapping (EFVM): Testing agency shall survey entire roof area for potential leaks using EFVM.

B. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.

1. Notify Architect and District 48 hours in advance of date and time of inspection.
3.8 PROTECTING AND CLEANING

A. Protect roofing system from damage and wear during remainder of construction period. When remaining construction does not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to Architect and Owner.

B. Correct deficiencies in or remove roofing system that does not comply with requirements, repair substrates, and repair or reinstall roofing system to a condition free of damage and deterioration at time of Substantial Completion and according to warranty requirements.

C. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION

Special Roof System Warranty follows.

PROTECTED MEMBRANE ROOF SYSTEM WARRANTY FORM

WHEREAS ___________________________ of ___________________________, herein called the "Protected Membrane Roofing Installer," has performed roofing and associated work ("Work") on the following project:

1. Owner: Contra Costa Community College District.
2. Building Name/Type: Contra Costa College New Science Building.
4. Acceptance Date: ________________.
5. Warranty Period: Two years from Date of Substantial Completion.
6. Expiration Date: ___________________.

AND WHEREAS Protected Membrane Roofing Installer has contracted (either directly with Owner or indirectly as a subcontractor) to warrant said work against leaks and faulty or defective materials and workmanship for designated Warranty Period,

NOW THEREFORE Protected Membrane Roofing Installer hereby warrants, subject to terms and conditions herein set forth, that during Warranty Period he will, at his own cost and expense, make or cause to be made such repairs to or replacements of said work as are necessary to correct faulty and defective work and as are necessary to maintain said work in a watertight condition.

This Warranty is made subject to the following terms and conditions:

Work includes: All components of fluid-applied protected roofing system such as roofing membrane, base flashings, roof insulation, protection boards, drainage panels, filter fabric, pavers and pedestals, fasteners and adhesive, and other components of protected membrane roofing system.

Specifically excluded from this Warranty are damages to work and other parts of the building, and to building contents, caused by:

a. lightning;
b. fire;
c. failure of roofing system substrate, including cracking, settlement, excessive deflection, deterioration, and decomposition;
d. faulty construction of parapet walls, copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the work;
e. vapor condensation on bottom of roofing; and
f. activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by Owner.
When work has been damaged by any of foregoing causes, Warranty shall be null and void until such damage has been repaired by Protected Membrane Roofing Installer and until cost and expense thereof have been paid by Owner or by another responsible party so designated.

Protected Membrane Roofing Installer is responsible for damage to work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of work.

During Warranty Period, if Owner allows alteration of work by anyone other than Protected Membrane Roofing Installer, including cutting, patching, and maintenance in connection with penetrations, attachment of other work, and positioning of anything on roof, this Warranty shall become null and void on date of said alterations, but only to the extent said alterations affect work covered by this Warranty. If Owner engages Roofing Installer to perform said alterations, Warranty shall not become null and void unless Protected Membrane Roofing Installer, before starting said work, shall have notified Owner in writing, showing reasonable cause for claim, that said alterations would likely damage or deteriorate work, thereby reasonably justifying a limitation or termination of this Warranty.

During Warranty Period, if original use of roof is changed and it becomes used for, other use or service more severe than originally specified, this Warranty shall become null and void on date of said change, but only to the extent said change affects work covered by this Warranty.

Owner shall promptly notify Protected Membrane Roofing Installer of observed, known, or suspected leaks, defects, or deterioration and shall afford reasonable opportunity for Roofing Installer to inspect work and to examine evidence of such leaks, defects, or deterioration.

This Warranty is recognized to be the only warranty of Protected Membrane Roofing Installer on said Work, unless otherwise indicated, and shall not operate to restrict or cut off Owner from other remedies and resources lawfully available to Owner in cases of roofing failure. Specifically, this Warranty shall not operate to relieve Protected Membrane Roofing Installer of responsibility for performance of original work according to requirements of the Contract Documents, regardless of whether Contract was a contract directly with Owner or a subcontract with Owner’s General Contractor.

IN WITNESS THEREOF, this instrument has been duly executed this _____ day of ______________, ____________.

Authorized Signature: _______________________________________.

Name: _______________________________________.

Title: _______________________________________.

END OF WARRANTY FORM
SECTION 076200 - SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Manufactured through-wall flashing with snaplock receiver.
   2. Manufactured reglets with counter flashing.
   3. Formed roof-drainage sheet metal fabrications.
   5. Formed wall sheet metal fabrications.
   6. Formed equipment support flashing.
   7. High-Temperature Underlayment.

B. Related Requirements:
   1. Section 061000 "Rough Carpentry" for wood nailers, curbs, and blocking.
   2. Section 077100 "Roof Specialties" for pre-manufactured sheet metal copings.
   3. Section 077200 "Roof Accessories" for set-on-type curbs, equipment supports, and other manufactured roof accessory units.
   4. Section 079513.16 "Exterior Expansion Joint Cover Assemblies" for manufactured expansion-joint cover assemblies for exterior building walls.

1.3 COORDINATION

A. Coordinate sheet metal flashing and trim layout and seams with sizes and locations of penetrations to be flashed, and joints and seams in adjacent materials.

B. Coordinate sheet metal flashing and trim installation with adjoining roofing and wall materials, joints, and seams to provide leakproof, secure, and noncorrosive installation.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review construction schedule. Verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
   2. Review special roof details, roof drainage, roof-penetration flashing, equipment curbs, and condition of other construction that affect sheet metal flashing and trim.
   3. Review requirements for insurance and certificates if applicable.
   4. Review sheet metal flashing observation and repair procedures after flashing installation.
1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each manufactured product and accessory.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For sheet metal flashing and trim.
   1. Include plans, elevations, sections, and attachment details.
   2. Detail fabrication and installation layouts, expansion-joint locations, and keyed details. Distinguish between shop- and field-assembled work.
   3. Include identification of material, thickness, weight, and finish for each item and location in Project.
   4. Include details for forming, including profiles, shapes, seams, and dimensions.
   5. Include details for joining, supporting, and securing, including layout and spacing of fasteners, cleats, clips, and other attachments. Include pattern of seams.
   6. Include details of termination points and assemblies.
   7. Include details of expansion joints and expansion-joint covers, including showing direction of expansion and contraction from fixed points.
   8. Include details of roof-penetration flashing.
   9. Include details of edge conditions, including eaves, ridges, valleys, rakes, crickets, and counterflashings as applicable.
  10. Include details of special conditions.
  11. Include details of connections to adjoining work.

D. Samples for Verification: For each type of exposed finish.
   1. Sheet Metal Flashing: 12 inches long by actual width of unit, including finished seam and in required profile. Include fasteners, cleats, clips, closures, and other attachments.
   2. Trim, Metal Closures, Expansion Joints, Joint Intersections, and Miscellaneous Fabrications: 12 inches long and in required profile. Include fasteners and other exposed accessories.
   3. Unit-Type Accessories and Miscellaneous Materials: Full-size Sample.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For sheet metal flashing and trim, and its accessories, to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Fabricator Qualifications: Employs skilled workers who custom fabricate sheet metal flashing and trim similar to that required for this Project and whose products have a record of successful in-service performance.
   1. For flashings that are SPRI ES-1 tested, shop shall be listed as able to fabricate required details as tested and approved.

B. Provide the following upon request:
   1. Qualification Data: For fabricator.
   2. Product Certificates: For each type of flashing that is SPRI ES-1 tested.
3. Product Test Reports: For each product, for tests performed by a qualified testing agency.

C. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.
   1. Include typical roof edge flashings as part of exterior project mockup, including supporting construction cleats, seams, attachments, underlayment, and accessories.
   2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Do not store sheet metal flashing and trim materials in contact with other materials that might cause staining, denting, or other surface damage. Store sheet metal flashing and trim materials away from uncured concrete and masonry.

B. Protect strippable protective covering on sheet metal flashing and trim from exposure to sunlight and high humidity, except to extent necessary for period of sheet metal flashing and trim installation.

1.9 WARRANTY

A. Special Warranty on Finishes: Manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within specified warranty period.
   1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
      a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
      b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
      c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
   2. Finish Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General: Sheet metal flashing and trim assemblies shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim shall not rattle, leak, or loosen, and shall remain watertight.

B. Sheet Metal Standard for Flashing and Trim: Comply with NRCA’s "The NRCA Roofing Manual" and SMACNA’s "Architectural Sheet Metal Manual" requirements for dimensions and profiles shown unless more stringent requirements are indicated.

C. SPRI Wind Design Standard: Manufacture and install roof edge flashings tested according to SPRI ES-1 and capable of resisting the following design pressure:
   1. Design Pressure: As indicated on Drawings.
D. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes to prevent buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
   1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 SHEET METALS

A. General: Protect mechanical and other finishes on exposed surfaces from damage by applying strippable, temporary protective film before shipping.

B. Aluminum Sheet: ASTM B 209, alloy as standard with manufacturer for finish required, with temper as required to suit forming operations and performance required; with smooth, flat surface.
   1. Exposed Coil-Coated Finish:
      a. Two-Coat Fluoropolymer: AAMA 2605. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
   2. Color: As selected by Architect from manufacturer's full range.
   3. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with minimum total dry film thickness of 0.5 mil.

C. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, Type 304, dead soft, fully annealed; with smooth, flat surface.
   1. Finish: 2D (dull, cold rolled).

D. Metallic-Coated Steel Sheet: Provide zinc-coated (galvanized) steel sheet according to ASTM A 653/A 653M, G90 coating designation or aluminum-zinc alloy-coated steel sheet according to ASTM A 792/A 792M, Class AZ50 coating designation, Grade 40; prepainted by coil-coating process to comply with ASTM A 755/A 755M.
   1. Surface: Smooth, flat.
   2. Exposed Coil-Coated Finish:
      a. Two-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
   3. Color: As selected by Architect from manufacturer's full range.
   4. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with minimum total dry film thickness of 0.5 mil.

2.3 UNDERLAYMENT MATERIALS

A. Felt: ASTM D 226/D 226M, Type II (No. 30), asphalt-saturated organic felt; nonperforated.
B. Self-Adhering, High-Temperature Sheet: 40 mils thick, smooth surfaced, self-adhering composite membrane consisting of 36 mils of butyl-modified or rubberized asphalt adhesive laminated to a 4-mil thick polyethylene-, polyolefin-, or polypropylene-film with release liner backing; specifically designed to withstand high temperatures beneath metal roofing, copings, flashings, and other non-roof detail area. Provide primer according to written recommendations of underlayment manufacturer. Coordinate and ensure compatibility with, and adhesion to, adjacent materials.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Carlisle Coatings & Waterproofing Inc., Carlisle Syntec; CCW WIP 300HT.
   b. GCP Applied Technologies (formerly Grace Construction Products; W.R. Grace & Co.); Grace Ice and Water Shield HT.
   c. Henry Company; Blueskin PE200 HT.
   d. Drexel Metals (formerly Metal-Fab Manufacturing, LLC); MetShield High-Temp Underlayment.
   e. Protecto Wrap Company; Protecto Jiffy Seal Ice & Water Guard HT.

4. Elongation at Break: ASTM D 412; Not less than 250 percent.

C. Slip Sheet: Rosin-sized building paper, 3 lb/100 sq. ft minimum.

2.4 MISCELLANEOUS MATERIALS
A. General: Provide materials and types of fasteners[solder], protective coatings, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and as recommended by manufacturer of primary sheet metal[or manufactured item] unless otherwise indicated.

B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal[or manufactured item].

1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.
   a. Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating. Provide metal-backed EPDM or PVC sealing washers under heads of exposed fasteners bearing on weather side of metal.
   b. Blind Fasteners: High-strength aluminum or stainless-steel rivets suitable for metal being fastened.
   c. Spikes and Ferrules: Same material as gutter; with spike with ferrule matching internal gutter width.

2. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.
3. Fasteners for Stainless-Steel Sheet: Series 300 stainless steel.
4. Fasteners for Zinc-Coated (Galvanized) and Aluminum-Zinc Alloy-Coated Steel Sheet: Series 300 stainless steel or hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329.

C. Solder:
1. For Stainless Steel: ASTM B 32, Grade Sn60, with acid flux of type recommended by stainless-steel sheet manufacturer.
2. For Zinc-Coated (Galvanized) Steel: ASTM B 32, Grade Sn50, 50 percent tin and 50 percent lead or Grade Sn60, 60 percent tin and 40 percent lead with maximum lead content of 0.2 percent.

D. Sealant Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch wide and 1/8 inch thick.

E. Elastomeric Sealant: ASTM C 920, elastomeric silicone polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

F. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type expansion joints with limited movement.

G. Epoxy Seam Sealer: Two-part, noncorrosive, aluminum seam-cementing compound, recommended by aluminum manufacturer for exterior nonmoving joints, including riveted joints.

H. Bituminous Coating: Cold-applied asphalt emulsion according to ASTM D 1187.


2.5 MANUFACTURED SHEET METAL FLASHING AND TRIM

A. Reglets: Units of type, material, and profile required, formed to provide secure interlocking of separate reglet and counterflashing pieces, and compatible with flashing indicated [with factory-mitered and -welded corners and junctions] [and] [with interlocking counterflashing on exterior face, of same metal as reglet].

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Cheney Flashing Company.
   b. Fry Reglet Corporation.
   c. Heckmann Building Products, Inc.
   d. Hickman Company, W. P.
   e. Hohmann & Barnard, Inc.
   f. Sandell Manufacturing Co., Inc.

2. Material: Stainless steel, 0.019 inch thick or metallic-coated steel, 0.022 inch thick.

3. Surface-Mounted Type: Provide with slotted holes for fastening to substrate, with neoprene or other suitable weatherproofing washers, and with channel for sealant at top edge.

4. Accessories:

   a. Flexible-Flashign Retainer: Provide resilient plastic or rubber accessory to secure flexible flashing in reglet where clearance does not permit use of standard metal counterflashing or where Drawings show reglet without metal counterflashing.

   b. Counterflashing Wind-Restraint Clips: Provide clips to be installed before counterflashing to prevent wind uplift of counterflashing's lower edge.
2.6 FABRICATION, GENERAL

A. General: Custom fabricate sheet metal flashing and trim to comply with details shown and recommendations in cited sheet metal standard that apply to design, dimensions, geometry, metal thickness, and other characteristics of item required. Fabricate sheet metal flashing and trim in shop to greatest extent possible.

1. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.
2. Obtain field measurements for accurate fit before shop fabrication.
3. Form sheet metal flashing and trim to fit substrates without excessive oil canning, buckling, and tool marks; true to line, levels, and slopes; and with exposed edges folded back to form hems.
4. Conceal fasteners and expansion provisions where possible. Do not use exposed fasteners on faces exposed to view.

B. Fabrication Tolerances: Fabricate sheet metal flashing and trim that is capable of installation to a tolerance of 1/4 inch in 20 feet on slope and location lines indicated on Drawings and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

C. Fabrication Tolerances: Fabricate sheet metal flashing and trim that is capable of installation to tolerances specified in MCA’s "Guide Specification for Residential Metal Roofing."

D. Expansion Provisions: Form metal for thermal expansion of exposed flashing and trim.

1. Form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with butyl sealant concealed within joints.
2. Use lapped expansion joints only where indicated on Drawings.

E. Sealant Joints: Where movable, nonexpansion-type joints are required, form metal to provide for proper installation of elastomeric sealant according to cited sheet metal standard.

F. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

G. Fabricate cleats and attachment devices of sizes as recommended by cited sheet metal standard and by FM Global Property Loss Prevention Data Sheet 1-49 for application, but not less than thickness of metal being secured.

H. Seams: Fabricate nonmoving seams with flat-lock seams. Tin edges to be seamed, form seams, and solder.

I. Seams: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use. Rivet joints where necessary for strength.

J. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints where necessary for strength.

K. Do not use graphite pencils to mark metal surfaces.
2.7 ROOF-DRAINAGE SHEET METAL FABRICATIONS

A. Downspouts: Fabricate rectangular downspouts to dimensions indicated, complete with mitered elbows. Furnish with metal hangers from same material as downspouts and anchors. Shop fabricate elbows.
   1. Fabricate from one of the following materials:
      a. Galvanized Steel: 0.022 inch thick.
      b. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch thick.

B. Parapet Scuppers: Fabricate scuppers to dimensions required, with closure flange trim to exterior, 4-inch- wide wall flanges to interior, and base extending 4 inches beyond cant or tapered strip into field of roof. Fabricate from the following materials:
   1. Galvanized Steel: 0.028 inch thick.
   2. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch thick.

C. Conductor Heads: Fabricate conductor heads with flanged back and stiffened top edge and of dimensions and shape required, complete with outlet tubes, exterior flange trim, and built-in overflows. Fabricate from one of the following materials:
   1. Galvanized Steel: 0.028 inch thick.
   2. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch thick.

D. Splash Pans: Fabricate to dimensions and shape required and from the following materials:
   1. Stainless Steel: 0.019 inch thick.

2.8 LOW-SLOPE ROOF SHEET METAL FABRICATIONS

A. Cap Flashing/Counterflashing Fabrication - General: Provide two-piece metal cap flashings, consisting of an upper receiver portion and a lower portion extending over the composition flashing, unless otherwise specified or indicated.
   1. Cap Flashing/Counterflashing Fabrication - Two Piece
      a. Fabricate the receiver portion with outer edge formed into a double fold turned down one inch, unless otherwise indicated, and as follows:
         1) At new masonry walls, extend the receiver portion into the wall as indicated, terminated with 1/4 inch upstand edge, unless indicated to be higher.
         2) At walls faced with metal siding or pre-formed metal panels, extend the receiver portion into the wall as indicated, and terminated with edge folded over support.
         3) At concrete and existing masonry walls, extend the receiver portion into an embedded reglet, sawcut in the profile indicated for a reglet, or form the receiver portion to retain sealant as indicated, using a 3/16 by one inch stainless steel clamping bar. SG: Note Drawing requirement and select one of the two subparagraphs below.
         4) At parapet, extend the receiver portion as indicated and form the upper edge to engage the double fold of coping
      b. Form the upper edge of the lower portion of metal cap flashing to engage in the double fold of receiver portion, bent to provide spring action against the base flashing, fold the lower edge folded back 1/2 inch and lap composition base flashing not less than 4 inches.
      c. Lap ends of each length of both portions of metal cap flashing not less than 3 inches. Weld or solder corner joints. Return ends at roof edge into reglet or wall.
2. Cap Flashing/Counterflashing Fabrication - One Piece
   a. Provide one-piece cap flashing at roof curbs, with top edge formed to retain metal joint sealant and bottom edge folded 1/2 inch to provide drip.

B. Base Flashing: Shop fabricate interior and exterior corners. Fabricate from one of the following materials:
   1. Galvanized Steel: 0.028 inch thick.
   2. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch thick.

C. Counterflashing: Shop fabricate interior and exterior corners. Fabricate from one of the following materials:
   1. Galvanized Steel: 0.022 inch thick.
   2. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch thick.

D. Flashing Receivers: Fabricate from one of the following materials:
   1. Galvanized Steel: 0.022 inch thick.
   2. Aluminum-Zinc Alloy-Coated Steel: 0.022 inch thick.

E. Roof-Penetration Flashing: Fabricate from the following materials:
   1. Stainless Steel: 0.019 inch thick.

F. Roof-Drain Flashing: Fabricate from the following materials:
   1. Stainless Steel: 0.016 inch thick.

2.9 WALL SHEET METAL FABRICATIONS

A. Through-Wall Flashing: Fabricate continuous flashings in minimum 96-inch-long, but not exceeding 12-foot-long, sections, under copings, and at shelf angles. Fabricate discontinuous lintel, sill, and similar flashings to extend 6 inches beyond each side of wall openings; and form with 2-inch-high, end dams. Fabricate from the following materials:
   1. Stainless Steel: 0.016 inch thick.

B. Opening Head Flashings in Frame Construction: Fabricate head, and similar flashings to extend 4 inches beyond wall openings. Form head flashing with 2-inch-high, end dams. Fabricate from one of the following materials:
   1. Galvanized Steel: [0.022 inch] <Insert dimension> thick.
   2. Aluminum-Zinc Alloy-Coated Steel: [0.022 inch] <Insert dimension> thick.

C. Opening Sill Pan Flashings in Frame Construction: Form sill pan flashing with 2-inch-high, end dams. Fabricate from the following materials:
   1. Aluminum: 0.032 inch thick.

D. Fascia:
   1. Fabricate fascia of aluminum sheets of the following thicknesses:
      a. Up to and including 5 inch vertical face dimension: 0.032 inch.
      b. 5 to 7 inch vertical face dimension: 0.040 inch.
      c. Over 7 inch vertical face dimension: 0.051 inch.
      d. Fabricate cleats of 0.051 inch.
2. Fabricate fascia of 0.018 inch thick stainless steel sheets.
   a. Fabricate cleats of 0.018 inch thick stainless steel strips.

3. Fabricate fascia and cleats of No. 22 gage galvanized steel.

4. Shop-fabricate fascia sections in 10 foot lengths and of one piece material of sufficient width.
   a. Form with upper edge of vertical face bent to form a 3/4 inch high gravel stop and with lower edge folded under 1/2 inch and bent out to hook over the cleat.
   b. Extend horizontal roof flange 4 inches onto roof
   c. Provide sections in one piece assemblies around internal and external corners, with vertical face bent and horizontal section mitered and welded or soldered.

5. Fabricate continuous cleat 1-3/4 inches wide, with one inch vertical leg and 3/4 inch leg bent out at 30 degrees, in sections of maximum practical length.

2.10 MISCELLANEOUS SHEET METAL FABRICATIONS

   A. Equipment Support Flashing: Fabricate from one of the following materials:
      1. Galvanized Steel: 0.028 inch thick.
      2. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch thick.

PART 3 - EXECUTION

3.1 EXAMINATION

   A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, substrate, and other conditions affecting performance of the Work.
      1. Verify compliance with requirements for installation tolerances of substrates.
      2. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.
      3. Verify that air- or water-resistant barriers have been installed over sheathing or backing substrate to prevent air infiltration or water penetration.

   B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 UNDERLAYMENT INSTALLATION

   A. Self-Adhering Sheet Underlayment: Install self-adhering sheet underlayment, wrinkle free. Prime substrate if recommended by underlayment manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation; use primer for installing underlayment at low temperatures. Apply in shingle fashion to shed water, with end laps of not less than 6 inches staggered 24 inches between courses. Overlap side edges not less than 3-1/2 inches. Roll laps and edges with roller. Cover underlayment within 14 days.

   B. Apply slip sheet, wrinkle free, [over underlayment] [directly on substrate] <Insert requirement> before installing sheet metal flashing and trim.
3.3 INSTALLATION, GENERAL

A. General: Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement. Use fasteners, solder, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.

1. Install sheet metal flashing and trim true to line, levels, and slopes. Provide uniform, neat seams with minimum exposure of solder, welds, and sealant.
2. Install sheet metal flashing and trim to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.
3. Space cleats not more than 12 inches apart. Attach each cleat with at least two fasteners. Bend tabs over fasteners.
4. Install exposed sheet metal flashing and trim with limited oil canning, and free of buckling and tool marks.
5. Torch cutting of sheet metal flashing and trim is not permitted.
6. Do not use graphite pencils to mark metal surfaces.

B. Metal Protection: Where dissimilar metals contact each other, or where metal contacts pressure-treated wood or other corrosive substrates, protect against galvanic action or corrosion by painting contact surfaces with bituminous coating or by other permanent separation as recommended by sheet metal manufacturer or cited sheet metal standard.

1. Coat concealed side of uncoated-aluminum and stainless-steel sheet metal flashing and trim with bituminous coating where flashing and trim contact wood, ferrous metal, or cementitious construction.
2. Underlayment: Where installing sheet metal flashing and trim directly on cementitious or wood substrates, install underlayment and cover with slip sheet.

C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at maximum of 10 feet with no joints within 24 inches of corner or intersection.

1. Form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with sealant concealed within joints.
2. Use lapped expansion joints only where indicated on Drawings.

D. Fasteners: Use fastener sizes that penetrate substrate not less than recommended by fastener manufacturer to achieve maximum pull-out resistance.

E. Conceal fasteners and expansion provisions where possible in exposed work and locate to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.

F. Seal joints as required for watertight construction.

1. Use sealant-filled joints unless otherwise indicated. Embed hooked flanges of joint members not less than 1 inch into sealant. Form joints to completely conceal sealant. When ambient temperature at time of installation is between 40 and 70 deg F, set joint members for 50 percent movement each way. Adjust setting proportionately for installation at higher ambient temperatures. Do not install sealant-type joints at temperatures below 40 deg F.
2. Prepare joints and apply sealants to comply with requirements in Section 079200 "Joint Sealants."
G. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter. Pre-tin edges of sheets with solder to width of 1-1/2 inches; however, reduce pre-tinning where pre-tinned surface would show in completed Work.

1. Do not solder metallic-coated steel and aluminum sheet.
2. Do not use torches for soldering.
3. Heat surfaces to receive solder, and flow solder into joint. Fill joint completely. Completely remove flux and spatter from exposed surfaces.

3.4 ROOF-DRAINAGE SYSTEM INSTALLATION

A. General: Install sheet metal roof-drainage items to produce complete roof-drainage system according to cited sheet metal standard unless otherwise indicated. Coordinate installation of roof perimeter flashing with installation of roof-drainage system.

B. Downspouts: Join sections with 1-1/2-inch telescoping joints.

1. Provide hangers with fasteners designed to hold downspouts securely to walls. Locate hangers at top and bottom and at approximately 60 inches o.c.
2. Provide elbows at base of downspout to direct water away from building.

C. Splash Pans: Install where downspouts discharge on low-slope roofs. Set in asphalt roofing cement or elastomeric sealant compatible with the substrate.

D. Parapet Scuppers: Continuously support scupper, set to correct elevation, and seal flanges to interior wall face, over cants or tapered edge strips, and under roofing membrane.

1. Anchor scupper closure trim flange to exterior wall and seal with elastomeric sealant to scupper.
2. Loosely lock front edge of scupper with conductor head.
3. Seal with elastomeric sealant exterior wall scupper flanges into back of conductor head.

E. Conductor Heads: Anchor securely to wall, with elevation of conductor head rim at minimum of 1 inch below scupper discharge.

3.5 ROOF FLASHING INSTALLATION

A. General: Install sheet metal flashing and trim to comply with performance requirements, sheet metal manufacturer's written installation instructions, and cited sheet metal standard. Provide concealed fasteners where possible, and set units true to line, levels, and slopes. Install work with laps, joints, and seams that are permanently watertight and weather resistant.

B. Roof Edge Flashing: Anchor to resist uplift and outward forces according to recommendations in FM Global Property Loss Prevention Data Sheet 1-49 for FM Approvals' listing for required windstorm classification.

C. Pipe or Post Counterflashing: Install counterflashing umbrella with close-fitting collar with top edge flared for elastomeric sealant, extending minimum of 4 inches over base flashing. Install stainless-steel draw band and tighten.

D. Cap Flashing/Counterflashing:
1. Coordinate installation of counterflashing with installation of base flashing.
2. Install metal cap flashing over composition base flashing which turns up into vertical surfaces.
3. In new masonry work, set flashing in a bed of mortar both above and below the metal.
4. At concrete and existing masonry walls, wedge the upper receiver portion of counter-flashing into a reglet with coiled metal plugs compatible with the receiver metal or neoprene wedges, 12 to 16 inches on center, unless otherwise indicated, or anchor stainless steel clamping bar to wall with screws and expansion shields as indicated.
5. Hook lower portion of counter-flashing into upper receiver portion of counter-flashing and fasten with screws at 12 inch spacing and of length required to join the metal but not project into substrate behind the flashing.
6. At roof curbs, apply metal joint sealant and install one-piece cap flashing as indicated.
7. Lap section ends a minimum of 3 inches and seal watertight with mastic.

E. Roof-Penetration Flashing: Coordinate installation of roof-penetration flashing with installation of roofing and other items penetrating roof. Seal with elastomeric sealant and clamp flashing to pipes that penetrate roof.

3.6 WALL FLASHING INSTALLATION

A. General: Install sheet metal wall flashing to intercept and exclude penetrating moisture according to cited sheet metal standard unless otherwise indicated. Coordinate installation of wall flashing with installation of wall-opening components such as windows, doors, and louvers.

B. Opening Flashings in Frame Construction: Install continuous head, sill, jamb, and similar flashings to extend 4 inches beyond wall openings.

C. Fascia:

1. Fasten continuous cleat to supporting construction with screws evenly spaced not over 12 inches on centers. Where construction is concrete or masonry, drive screws into lead expansion shields set into the substrate. Install strip to extend over the supporting construction to form a drip and to allow the metal fascia to be hooked over the lower edge 3/4 inch.
2. Install fascia with horizontal flange over roofing plies, set in mastic and with lower edge hooked to metal edge strip. Nail horizontal flange to wood blocking at maximum spacing of 3 inches, staggered.
3. Lap joints 3 inches minimum, held together by concealed clips welded or soldered to underside, and fill with metal joint sealant.
4. Do not use exposed nails or other fasteners on face of metal fascia.

3.7 MISCELLANEOUS FLASHING INSTALLATION

A. Equipment Support Flashing: Coordinate installation of equipment support flashing with installation of roofing and equipment. Weld or seal flashing with elastomeric sealant to equipment support member.

3.8 ERECTION TOLERANCES

A. Installation Tolerances: Shim and align sheet metal flashing and trim within installed tolerance of 1/4 inch in 20 feet on slope and location lines indicated on Drawings and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.
B. Installation Tolerances: Shim and align sheet metal flashing and trim within installed tolerances specified in MCA's "Guide Specification for Residential Metal Roofing."

3.9 CLEANING AND PROTECTION

A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

B. Clean and neutralize flux materials. Clean off excess solder.

C. Clean off excess sealants.

D. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions. On completion of sheet metal flashing and trim installation, remove unused materials and clean finished surfaces as recommended by sheet metal flashing and trim manufacturer. Maintain sheet metal flashing and trim in clean condition during construction.

E. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION
SECTION 077200 - ROOF ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Roof curbs.
   2. Equipment supports.
   3. Pipe and duct supports.
   4. Pipe portals.
   5. Preformed flashing sleeves.

B. Related Requirements:
   1. Section 076200 "Sheet Metal Flashing and Trim" for shop- and field-formed metal flashing, and miscellaneous sheet metal trim and accessories.
   2. Section 077100 "Roof Specialties" for manufactured copings, gutters and downspouts, and counterflashing.
   3. Division 23 "Vibration and Seismic Controls for HVAC" for special curbs designed to accommodate seismic and vibration controls.

1.3 COORDINATION

A. Coordinate layout and installation of roof accessories with [roofing membrane and base flashing and ]interfacing and adjoining construction to provide a leakproof, weathertight, secure, and noncorrosive installation.

B. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of roof accessory.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For roof accessories.
   1. Include plans, elevations, keyed details, and attachments to other work. Indicate dimensions, loadings, and special conditions. Distinguish between plant- and field-assembled work.
D. Samples: For each exposed product and for each color and texture specified, prepared on Samples of size to adequately show color.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof plans, drawn to scale, and coordinating penetrations and roof-mounted items. Show the following:
   1. Size and location of roof accessories specified in this Section.
   2. Method of attaching roof accessories to roof or building structure.
   3. Other roof-mounted items including mechanical and electrical equipment, ductwork, piping, and conduit.
   4. Required clearances.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For roof accessories to include in operation and maintenance manuals.

1.7 WARRANTY

A. Special Warranty on Painted Finishes: Manufacturer's standard form in which manufacturer agrees to repair finishes or replace roof accessories that show evidence of deterioration of factory-applied finishes within specified warranty period.
   1. Fluoropolymer Finish: Deterioration includes, but is not limited to, the following:
      a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
      b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
      c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
   2. Finish Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Roof accessories installation shall withstand exposure to weather and resist thermally induced movement without failure, rattling, leaking, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.

B. Wind-Restraint Performance: As indicated on Drawings.

2.2 ROOF CURBS

A. Roof Curbs: Internally reinforced roof-curb units capable of supporting superimposed live and dead loads, including equipment loads and other construction indicated on Drawings, bearing continuously on roof structure, and capable of meeting performance requirements; with welded or mechanically fastened and sealed corner joints, straight sides, integral metal cant, and integrally formed deck-mounting flange at perimeter bottom.

   1. Manufacturers: Subject to compliance with requirements, available manufacturers
offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Greenheck Fan Corporation.
b. Milcor; Commercial Products Group of Hart & Cooley, Inc.
c. Pate Company (The).
d. Roof Curb Systems Inc.
e. Roof Products, Inc.

B. Size: Coordinate dimensions with roughing-in information or Shop Drawings of equipment to be supported.

C. Supported Load Capacity: Refer to Drawings.

D. Material: Zinc-coated (galvanized) or Aluminum-zinc alloy-coated steel sheet, 0.079 inch thick.
   1. Finish: Two-coat fluoropolymer.
   2. Color: As selected by Architect from manufacturer's full range.

E. Material: Aluminum sheet, 0.125 inch thick.
   1. Finish: Two-coat fluoropolymer.
   2. Color: As selected by Architect from manufacturer's full range.

F. Material: Stainless-steel sheet, 0.078 inch thick.
   1. Finish: Manufacturer's standard.

G. Construction:
   1. Curb Profile: Manufacturer's standard compatible with roofing system.
   2. Fabricate curbs to minimum height of 12 inches above roofing surface unless otherwise indicated.
   3. Top Surface: Level top of curb, with roof slope accommodated by sloping deck-mounting flange or by use of leveler frame.
   4. Sloping Roofs: Where roof slope exceeds 1:48, fabricate curb with perimeter curb height tapered to accommodate roof slope so that top surface of perimeter curb is level. Equip unit with water diverter or cricket on side that obstructs water flow.
   5. Insulation: Factory insulated with 1-1/2-inch thick glass-fiber board insulation.
   6. Liner: Same material as curb, of manufacturer's standard thickness and finish.
   8. Wind Restraint Straps and Base Flange Attachment: Provide wind restraint straps, welded strap connectors, and base flange attachment to roof structure at perimeter of curb, of size and spacing required to meet wind uplift requirements.
   9. Platform Cap: Where portion of roof curb is not covered by equipment, provide weathertight platform cap formed from 3/4-inch thick plywood covered with metal sheet of same type, thickness, and finish as required for curb.
   10. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as curb.

2.3 EQUIPMENT SUPPORTS

A. Equipment Supports: Internally reinforced perimeter metal equipment supports capable of supporting superimposed live and dead loads between structural supports, including equipment loads and other construction indicated on Drawings, spanning between structural supports;
capable of meeting performance requirements; with welded or mechanically fastened and sealed corner joints, integral metal cant, and integrally formed structure-mounting flange at bottom.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Greenheck Fan Corporation.
   b. Milcor; Commercial Products Group of Hart & Cooley, Inc.
   c. Pate Company (The).
   d. Roof Curb Systems Inc.
   e. Roof Products, Inc.

B. Size: Coordinate dimensions with roughing-in information or Shop Drawings of equipment to be supported.

C. Supported Load Capacity: Refer to Drawings.

D. Material: Zinc-coated (galvanized) or Aluminum-zinc alloy-coated steel sheet, 0.079 inch thick.
   1. Finish: Two-coat fluoropolymer.
   2. Color: As selected by Architect from manufacturer's full range.

E. Material: Aluminum sheet, [0.090 inch] [0.125 inch] <Insert dimension> thick.
   1. Finish: Two-coat fluoropolymer.
   2. Color: As selected by Architect from manufacturer's full range.

F. Material: Stainless-steel sheet, 0.078 inch thick.
   1. Finish: Manufacturer's standard.

G. Construction:
   1. Curb Profile: Manufacturer's standard compatible with roofing system.
   2. Insulation: Factory insulated with 1-1/2-inch-thick glass-fiber board insulation.
   3. Liner: Same material as equipment support, of manufacturer's standard thickness and finish.
   4. Nailer: Factory-installed continuous wood nailers 5-1/2 inches wide on top flange of equipment supports, continuous around support perimeter.
   5. Wind Restraint Straps and Base Flange Attachment: Provide wind restraint straps, welded strap connectors, and base flange attachment to roof structure at perimeter of curb of size and spacing required to meet wind uplift requirements.
   6. Platform Cap: Where portion of equipment support is not covered by equipment, provide weathertight platform cap formed from 3/4-inch-thick plywood covered with metal sheet of same type, thickness, and finish as required for curb.
   7. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as equipment support.
   8. Fabricate equipment supports to minimum height of 12 inches above roofing surface unless otherwise indicated.
   9. Sloping Roofs: Where roof slope exceeds 1:48, fabricate each support with height to accommodate roof slope so that tops of supports are level with each other. Equip supports with water diverters or crickets on sides that obstruct water flow.
   10. Security Grille: Provide where indicated on Drawings.
2.4 PIPE AND DUCT SUPPORTS

A. Pipe Supports: As indicated in Structural and Mechanical Drawings.

B. Duct Supports: As indicated in Structural and Mechanical Drawings.

2.5 PIPE PORTALS

A. Curb-Mounted Pipe Portal: Insulated roof-curb units with welded or mechanically fastened and sealed corner joints, straight sides, integral metal cant, and integrally formed deck-mounting flange at perimeter bottom; with weathertight curb cover with single or multiple collared openings and pressure-sealed conically shaped EPDM protective rubber caps sized for piping indicated, with stainless-steel snaplock swivel clamps.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Roof Products and Systems (RPS); a division of Hart & Cooley, Inc.

B. Flashing Pipe Portal: Formed aluminum membrane-mounting flashing flange and sleeve with collared opening and pressure-sealed conically shaped EPDM protective rubber cap sized for piping indicated, with stainless-steel snaplock swivel clamps.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Roof Products and Systems (RPS); a division of Hart & Cooley, Inc.
2.6 PREFORMED FLASHING SLEEVES

A. Exhaust Vent Flashing: Double-walled metal flashing sleeve or boot, insulation filled, with integral deck flange, 12 inches high, with removable metal hood and slotted or perforated metal collar.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Custom Solution Roof and Metal Products.
      b. Thaler Metal Industries Ltd.
   2. Metal: Aluminum sheet, 0.063 inch thick.
   3. Diameter: As indicated on Drawings.

B. Vent Stack Flashing: Metal flashing sleeve, uninsulated, with integral deck flange.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Custom Solution Roof and Metal Products.
      b. Milcor; Commercial Products Group of Hart & Cooley, Inc.
      c. Thaler Metal Industries Ltd.
   3. Height: 13 inches.
   4. Diameter: As indicated on Drawings.
   5. Finish: Manufacturer's standard.

2.7 METAL MATERIALS

A. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, G90 coating designation[ and mill phosphatized for field painting where indicated].
   1. Factory Prime Coating: Where field painting is indicated, apply pretreatment and white or light-colored, factory-applied, baked-on epoxy primer coat, with a minimum dry film thickness of 0.2 mil.
   2. Exposed Coil-Coated Finish: Prepainted by the coil-coating process to comply with ASTM A 755/A 755M. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
      a. Two-Coat Fluoropolymer Finish: AAMA 621. System consisting of primer and fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight.
   3. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester-backer finish consisting of prime coat and wash coat, with a minimum total dry film thickness of 0.5 mil.

B. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, AZ50 coated.
   1. Factory Prime Coating: Where field painting is indicated, apply pretreatment and white or light-colored, factory-applied, baked-on epoxy primer coat, with a minimum dry film thickness of 0.2 mil.
   2. Exposed Coil-Coated Finish: Prepainted by the coil-coating process to comply with ASTM A 755/A 755M. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
a. Two-Coat Fluoropolymer Finish: AAMA 621. System consisting of primer and fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight.

3. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester-backer finish consisting of prime coat and wash coat, with a minimum total dry film thickness of 0.5 mil.

C. Aluminum Sheet: ASTM B 209, manufacturer's standard alloy for finish required, with temper to suit forming operations and performance required.

1. Mill Finish: As manufactured.
2. Factory Prime Coating: Where field painting is indicated, apply pretreatment and white or light-colored, factory-applied, baked-on epoxy primer coat, with a minimum dry film thickness of 0.2 mil.
3. Exposed Coil-Coated Finish: Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
   a. Two-Coat Fluoropolymer Finish: AAMA 2605. System consisting of primer and fluoropolymer color topcoat containing not less than 70 percent PVDF resin by weight.

4. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester-backer finish consisting of prime coat and wash coat, with a minimum total dry film thickness of 0.5 mil.

D. Aluminum Extrusions and Tubes: ASTM B 221, manufacturer's standard alloy and temper for type of use, finished to match assembly where used; otherwise mill finished.

E. Stainless-Steel Sheet and Shapes: ASTM A 240/A 240M or ASTM A 666, Type 316.

F. Steel Shapes: ASTM A 36/A 36M, hot-dip galvanized according to ASTM A 123/A 123M unless otherwise indicated.

G. Galvanized-Steel Tube: ASTM A 500/A 500M, round tube, hot-dip galvanized according to ASTM A 123/A 123M.


2.8 MISCELLANEOUS MATERIALS

A. General: Provide materials and types of fasteners, protective coatings, sealants, and other miscellaneous items required by manufacturer for a complete installation.

B. Glass-Fiber Board Insulation: ASTM C 726, nominal density of 3 lb/cu. ft., thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F, thickness as indicated.

C. Polyisocyanurate Board Insulation: ASTM C 1289, thickness and thermal resistivity as indicated.

D. Wood Nailers: Softwood lumber, pressure treated with waterborne preservatives for aboveground use, acceptable to authorities having jurisdiction, containing no arsenic or chromium, and complying with AWPA C2; not less than 1-1/2 inches thick.

E. Security Grilles: 3/4-inch diameter, ASTM A 1011/A 1011M steel bars spaced 6 inches o.c. in one direction and 12 inches o.c. in the other; factory finished as follows:
1. Surface Preparation: Remove mill scale and rust, if any, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."

2. Factory Priming for Field-Painted Finish: Apply shop primer specified below immediately after surface preparation and pretreatment.

3. Shop Primer: Manufacturer's or fabricator's standard, fast-curing, lead- and chromate-free, universal primer; selected for resistance to normal atmospheric corrosion, for compatibility with substrate and field-applied finish paint system indicated, and for capability to provide a sound foundation for field-applied topcoats under prolonged exposure.

F. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187/D 1187M.

G. Underlayment:
   1. Slip Sheet: Building paper, 3 lb/100 sq. ft. minimum, rosin sized.
   2. Self-Adhering, High-Temperature Sheet: Minimum 30 to 40 mils thick, consisting of slip-resisting polyethylene-film top surface laminated to layer of butyl or SBS-modified asphalt adhesive, with release-paper backing; cold applied. Provide primer when recommended by underlayment manufacturer.
   3. Fasteners: Roof accessory manufacturer's recommended fasteners suitable for application and metals being fastened. Match finish of exposed fasteners with finish of material being fastened. Provide nonremovable fastener heads to exterior exposed fasteners. Furnish the following unless otherwise indicated:
      4. Fasteners for Zinc-Coated or Aluminum-Zinc Alloy-Coated Steel: Series 300 stainless steel or hot-dip zinc-coated steel according to ASTM A 153/A 153M or ASTM F 2329.
      5. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.
      6. Fasteners for Stainless-Steel Sheet: Series 300 stainless steel.

H. Gaskets: Manufacturer's standard tubular or fingered design of neoprene, EPDM, PVC, or silicone or a flat design of foam rubber, sponge neoprene, or cork.

I. Elastomeric Sealant: ASTM C 920, elastomeric silicone polymer sealant as recommended by roof accessory manufacturer for installation indicated; low modulus; of type, grade, class, and use classifications required to seal joints and remain watertight.

J. Butyl Sealant: ASTM C 1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for expansion joints with limited movement.


2.9 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of the Work.

B. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.

C. Verify dimensions of roof openings for roof accessories.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install roof accessories according to manufacturer's written instructions.
   1. Install roof accessories level; plumb; true to line and elevation; and without warping, jogs in alignment, buckling, or tool marks.
   2. Anchor roof accessories securely in place so they are capable of resisting indicated loads.
   3. Use fasteners, separators, sealants, and other miscellaneous items as required to complete installation of roof accessories and fit them to substrates.
   4. Install roof accessories to resist exposure to weather without failing, rattling, leaking, or loosening of fasteners and seals.

B. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.
   1. Coat concealed side of uncoated aluminum roof accessories with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
   2. Underlayment: Where installing roof accessories directly on cementitious or wooden substrates, install a course of underlayment and cover with manufacturer's recommended slip sheet.

C. Roof Curb Installation: Install each roof curb so top surface is level Refer to Drawings for additional information.

D. Equipment Support Installation: Install equipment supports so top surfaces are level with each other.

E. Pipe Support Installation: Comply with MSS SP-58 and MSS SP-89. Install supports and attachments as required to properly support piping. Arrange for grouping of parallel runs of horizontal piping, and support together.
   1. Pipes of Various Sizes: Space supports for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
F. Preformed Flashing-Sleeve and Flashing Pipe Portal Installation: Secure flashing sleeve to roof membrane according to flashing-sleeve manufacturer's written instructions; flash sleeve flange to surrounding roof membrane according to roof membrane manufacturer's instructions.

G. Security Grilles: Weld bar intersections and ends of bars to structural frame or primary curb walls.

H. Seal joints with elastomeric butyl sealant as required by roof accessory manufacturer.

3.3 REPAIR AND CLEANING

A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing according to ASTM A 780/A 780M.

B. Touch up factory-primed surfaces with compatible primer ready for field painting according to Section 099113 "Exterior Painting."

C. Clean exposed surfaces according to manufacturer's written instructions.

D. Clean off excess sealants.

E. Replace roof accessories that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures.

END OF SECTION
SECTION 078413 - PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section Includes:
      1. Penetrations in fire-resistance-rated walls.
      2. Penetrations in horizontal assemblies.
      3. Penetrations in smoke barriers.

1.3 ACTION SUBMITTALS
   A. Product Data:  For each type of product indicated.
   B. Sustainable Design Submittals required by Section 01813 applicable to this Section.
   C. Product Schedule:  For each penetration firestopping system. Include location and design designation of qualified testing and inspecting agency.
      1. Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular penetration firestopping condition, submit illustration, with modifications marked, approved by penetration firestopping manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.

1.4 QUALITY ASSURANCE
   A. Installer Qualifications:  A firm that has been approved by FM Global according to FM Global 4991, “Approval of Firestop Contractors,” or been evaluated by UL and found to comply with its "Qualified Firestop Contractor Program Requirements."
   B. Installer Qualifications:  A firm experienced in installing penetration firestopping similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance. Qualifications include having the necessary experience, staff, and training to install manufacturer's products per specified requirements. Manufacturer's willingness to sell its penetration firestopping products to Contractor or to Installer engaged by Contractor does not in itself confer qualification on buyer.
   C. Installation Responsibility: Assign installation of penetration firestopping and fire-resistive joint systems to a single qualified firestop contractor.
   D. Fire-Test-Response Characteristics: Penetration firestopping shall comply with the following requirements:
      1. Penetration firestopping tests are performed by a qualified testing agency acceptable to authorities having jurisdiction.
2. Penetration firestopping is identical to those tested per testing standard referenced in "Penetration Firestopping" Article. Provide rated systems complying with the following requirements:
   a. Penetration firestopping products bear classification marking of qualified testing and inspecting agency.
   b. Classification markings on penetration firestopping correspond to designations listed by one of the following:
      1) UL in its "Fire Resistance Directory."
      2) Intertek ETL SEMKO in its "Directory of Listed Building Products."
      3) FM Global in its "Building Materials Approval Guide."

E. Provide the following upon request:
   1. Qualification Data: For qualified Installer.
   2. Installer Certificates: From Installer indicating penetration firestopping has been installed in compliance with requirements and manufacturer's written recommendations.
   3. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for penetration firestopping.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: Do not install penetration firestopping when ambient or substrate temperatures are outside limits permitted by penetration firestopping manufacturers or when substrates are wet because of rain, frost, condensation, or other causes.

B. Install and cure penetration firestopping per manufacturer's written instructions using natural means of ventilations or, where this is inadequate, forced-air circulation.

1.6 COORDINATION

A. Coordinate construction of openings and penetrating items to ensure that penetration firestopping is installed according to specified requirements.

B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate penetration firestopping.

C. Notify District's testing agency at least seven days in advance of penetration firestopping installations; confirm dates and times on day preceding each series of installations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Hilti, Inc.
   3. Specified Technologies Inc.
   4. 3M Fire Protection Products.
2.2 PENETRATION FIRESTOPPING

A. Provide penetration firestopping that is produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any.

B. Penetrations in Fire-Resistance-Rated Walls: Provide penetration firestopping with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.
   1. Fire-resistance-rated walls include fire walls, fire-barrier walls, smoke-barrier walls, and fire partitions, as occur.
   2. F-Rating: Not less than the fire-resistance rating of constructions penetrated.

C. Penetrations in Horizontal Assemblies: Provide penetration firestopping with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.
   1. Horizontal assemblies include floors, floor/ceiling assemblies and ceiling membranes of roof/ceiling assemblies, as occur.
   2. F-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated.
   3. T-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated except for floor penetrations within the cavity of a wall.

D. Penetrations in Smoke Barriers: Provide penetration firestopping with ratings determined per UL 1479.
   1. L-Rating: Not exceeding 5.0 cfm/sq. ft. of penetration opening at 0.30-inch wg at both ambient and elevated temperatures.

E. W-Rating: Provide penetration firestopping showing no evidence of water leakage when tested according to UL 1479.

F. Exposed Penetration Firestopping: Provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

G. VOC Content: Penetration firestopping sealants and sealant primers shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
   1. Sealants: 250 g/L.
   2. Sealant Primers for Nonporous Substrates: 250 g/L.
   3. Sealant Primers for Porous Substrates: 775 g/L.

H. Accessories: Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping manufacturer and approved by qualified testing and inspecting agency for firestopping indicated.
   1. Permanent forming/damming/backing materials, including the following:
      a. Slag-wool-fiber or rock-wool-fiber insulation.
      b. Sealants used in combination with other forming/damming/backing materials to prevent leakage of fill materials in liquid state.
      c. Fire-rated form board.
      d. Fillers for sealants.
   2. Temporary forming materials.
5. Steel sleeves.

2.3 FILL MATERIALS

A. Cast-in-Place Firestop Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer metallic sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.

B. Latex Sealants: Single-component latex formulations that do not re-emulsify after cure during exposure to moisture.

C. Firestop Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.

D. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced elastomeric sheet bonded to galvanized-steel sheet.

E. Intumescent Putties: Nonhardening dielectric, water-resistant putties containing no solvents, inorganic fibers, or silicone compounds.

F. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.

G. Mortars: Prepackaged dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers, and lightweight aggregate formulated for mixing with water at Project site to form a nonshrinking, homogeneous mortar.

H. Pillows/Bags: Reusable heat-expanding pillows/bags consisting of glass-fiber cloth cases filled with a combination of mineral-fiber, water-insoluble expansion agents, and fire-retardant additives. Where exposed, cover openings with steel-reinforcing wire mesh to protect pillows/bags from being easily removed.

I. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

J. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below:

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces, and nonsag formulation for openings in vertical and sloped surfaces, unless indicated firestopping limits use of nonsag grade for both opening conditions.

2.4 MIXING

A. For those products requiring mixing before application, comply with penetration firestopping manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning: Clean out openings immediately before installing penetration firestopping to comply with manufacturer's written instructions and with the following requirements:
   1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of penetration firestopping.
   2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with penetration firestopping. Remove loose particles remaining from cleaning operation.
   3. Remove laitance and form-release agents from concrete.

B. Priming: Prime substrates where recommended in writing by manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Masking Tape: Use masking tape to prevent penetration firestopping from contacting adjoining surfaces that will remain exposed on completion of the Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove stains. Remove tape as soon as possible without disturbing firestopping's seal with substrates.

3.3 INSTALLATION

A. General: Install penetration firestopping to comply with manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.
   1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of firestopping.

C. Install fill materials for firestopping by proven techniques to produce the following results:
   1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
   2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
   3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.
3.4 **IDENTIFICATION**

A. Identify penetration firestopping with preprinted metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6 inches of firestopping edge so labels will be visible to anyone seeking to remove penetrating items or firestopping. Use mechanical fasteners or self-adhering-type labels with adhesives capable of permanently bonding labels to surfaces on which labels are placed. Include the following information on labels:

1. The words "Warning - Penetration Firestopping - Do Not Disturb. Notify Building Management of Any Damage."
2. Contractor's name, address, and phone number.
3. Designation of applicable testing and inspecting agency.
4. Date of installation.
5. Manufacturer's name.
6. Installer's name.

3.5 **FIELD QUALITY CONTROL**

A. District will engage a qualified testing agency to perform tests and inspections.

B. Where deficiencies are found or penetration firestopping is damaged or removed because of testing, repair or replace penetration firestopping to comply with requirements.

C. Proceed with enclosing penetration firestopping with other construction only after inspection reports are issued and installations comply with requirements.

3.6 **CLEANING AND PROTECTION**

A. Clean off excess fill materials adjacent to openings as the Work progresses by methods and with cleaning materials that are approved in writing by penetration firestopping manufacturers and that do not damage materials in which openings occur.

B. Provide final protection and maintain conditions during and after installation that ensure that penetration firestopping is without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, immediately cut out and remove damaged or deteriorated penetration firestopping and install new materials to produce systems complying with specified requirements.

3.7 **PENETRATION FIRESTOPPING SCHEDULE**

A. Where UL-classified systems are indicated, they refer to system numbers in UL's "Fire Resistance Directory" under product Category XHEZ.

B. Where Intertek ETL SEMKO-listed systems are indicated, they refer to design numbers in Intertek ETL SEMKO's "Directory of Listed Building Products" under "Firestop Systems."

C. Where FM Global-approved systems are indicated, they refer to design numbers listed in FM Global's "Building Materials Approval Guide" under "Wall and Floor Penetration Fire Stops."

END OF SECTION
SECTION 078443 - JOINT FIRESTOPPING AND FIRESAFING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Joints in or between fire-resistance-rated constructions.
   2. Joints at exterior curtain-wall/floor intersections.

B. Related Requirements:
   1. Section 078413 "Penetration Firestopping" for penetrations in fire-resistance-rated walls, horizontal assemblies, and smoke barriers and for wall identification.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Product Schedule: For each joint firestopping system. Include location, illustration of firestopping system, and design designation of qualified testing agency.
   1. Engineering Judgments: Where Project conditions require modification to a qualified testing agency's illustration for a particular joint firestopping system condition, submit illustration, with modifications marked, approved by joint firestopping system manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly.

1.5 CLOSEOUT SUBMITTALS

A. Installer Certificates: From Installer indicating that joint firestopping systems have been installed in compliance with requirements and manufacturer's written instructions.
1.6 QUALITY ASSURANCE

A. Installer Qualifications: A firm that has been approved by FM Global according to FM Global 4991, "Approval of Firestop Contractors," or been evaluated by UL and found to comply with UL's "Qualified Firestop Contractor Program Requirements."

B. Provide the following upon request:
   1. Qualification Data: For Installer.
   2. Product Test Reports: For each joint firestopping system, for tests performed by a qualified testing agency.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not install joint firestopping systems when ambient or substrate temperatures are outside limits permitted by joint firestopping system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Install and cure joint firestopping systems per manufacturer's written instructions using natural means of ventilation or, where this is inadequate, forced-air circulation.

1.8 COORDINATION

A. Coordinate construction of joints to ensure that joint firestopping systems can be installed according to specified firestopping system design.

B. Coordinate sizing of joints to accommodate joint firestopping systems.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics:
   1. Perform joint firestopping system tests by a qualified testing agency acceptable to authorities having jurisdiction.
   2. Test per testing standards referenced in "Joint Firestopping Systems" Article. Provide rated systems complying with the following requirements:
      a. Joint firestopping systems shall bear classification marking of a qualified testing agency.
         1) UL in its "Fire Resistance Directory."
         2) Intertek Group in its "Directory of Listed Building Products."

2.2 JOINT FIRESTOPPING SYSTEMS

A. Joint Firestopping Systems: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of assemblies in or between which joint firestopping systems are installed. Joint firestopping systems shall accommodate building movements without impairing their ability to resist the passage of fire and hot gases.
B. Joints in or between Fire-Resistance-Rated Construction: Provide joint firestopping systems with ratings determined per ASTM E 1966 or UL 2079.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Rockwool (formerly Roxul Inc.).
      b. Thermafiber, Inc.; an Owens Corning company.
      c. Tremco, Inc.
   2. Fire-Resistance Rating: Equal to or exceeding the fire-resistance rating of the wall, floor, or roof in or between which it is installed.

C. Joints at Exterior Curtain-Wall/Floor Intersections: Provide mineral wool joint firestopping systems with rating determined per ASTM E 2307; minimum density of 4 lbs per cu. ft..
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Rockwool (formerly Roxul Inc.).
      b. Thermafiber, Inc.; an Owens Corning company.
      c. Tremco, Inc.
   2. F-Rating: Equal to or exceeding the fire-resistance rating of the floor assembly.

D. Joints in Smoke Barriers: Provide fire-resistive joint systems with ratings determined per UL 2079 based on testing at a positive pressure differential of 0.30-inch wg.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Rockwool (formerly Roxul Inc.).
      b. Thermafiber, Inc.; an Owens Corning company.
      c. Tremco, Inc.
   2. L-Rating: Not exceeding 5.0 cfm/ft. of joint at both ambient and elevated temperatures.

E. Exposed Joint Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.
   1. Sealant shall have a VOC content of 250 g/L or less.

F. Accessories: Provide components of fire-resistive joint systems, including primers and forming materials, that are needed to install elastomeric fill materials and to maintain ratings required. Use only components specified by joint firestopping system manufacturer and approved by the qualified testing agency for conditions indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for joint configurations, substrates, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 PREPARATION

A. Surface Cleaning: Before installing fire-resistive joint systems, clean joints immediately to comply with fire-resistive joint system manufacturer's written instructions and the following requirements:
   1. Remove from surfaces of joint substrates foreign materials that could interfere with adhesion of elastomeric fill materials or compromise fire-resistive rating.
   2. Clean joint substrates to produce clean, sound surfaces capable of developing optimum bond with elastomeric fill materials. Remove loose particles remaining from cleaning operation.
   3. Remove laitance and form-release agents from concrete.

B. Prime substrates where recommended in writing by joint firestopping system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

3.3 INSTALLATION

A. General: Install fire-resistive joint systems to comply with manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming materials and other accessories of types required to support elastomeric fill materials during their application and in position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.
   1. After installing elastomeric fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of fire-resistive joint system.

C. Install elastomeric fill materials for fire-resistive joint systems by proven techniques to produce the following results:
   1. Elastomeric fill voids and cavities formed by joints and forming materials as required to achieve fire-resistance ratings indicated.
   2. Apply elastomeric fill materials so they contact and adhere to substrates formed by joints.
   3. For elastomeric fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.4 IDENTIFICATION

A. Joint Identification: Identify joint firestopping systems with legible metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6 inches of joint edge so labels are visible to anyone seeking to remove or joint firestopping system. Use mechanical fasteners or self-adhering-type labels with adhesives capable of permanently bonding labels to surfaces on which labels are placed. Include the following information on labels:
   2. Contractor's name, address, and phone number.
   3. Designation of applicable testing agency.
   4. Date of installation.
   5. Manufacturer's name.
   6. Installer's name.
3.5 FIELD QUALITY CONTROL

A. Inspecting Agency: District will engage a qualified testing agency to perform tests and inspections according to ASTM E 2393.

B. Where deficiencies are found or joint firestopping systems are damaged or removed due to testing, repair or replace joint firestopping systems so they comply with requirements.

C. Proceed with enclosing joint firestopping systems with other construction only after inspection reports are issued and installations comply with requirements.

3.6 CLEANING AND PROTECTION

A. Clean off excess elastomeric fill materials adjacent to joints as the Work progresses by methods and with cleaning materials that are approved in writing by joint firestopping system manufacturers and that do not damage materials in which joints occur.

B. Provide final protection and maintain conditions during and after installation that ensure joint firestopping systems are without damage or deterioration at time of Substantial Completion. If damage or deterioration occurs despite such protection, cut out and remove damaged or deteriorated fire-resistive joint systems immediately and install new materials to produce fire-resistive joint systems complying with specified requirements.

3.7 JOINT FIRESTOPPING SYSTEM SCHEDULE

A. Where UL-classified systems are indicated, they refer to system numbers in UL's "Fire Resistance Directory" under product Category XHBN or Category XHDG.

B. Where Intertek Group-listed systems are indicated, they refer to design numbers in Intertek Group's "Directory of Listed Building Products" under product category Firestop Systems.

END OF SECTION
SECTION 079200 - JOINT SEALANTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Silicone joint sealants.
   2. Urethane joint sealants.
   3. Latex joint sealants.
   4. Preformed joint sealants.
   5. Acoustical joint sealants.

B. Related Requirements:
   1. Section 078443 "Joint Firestopping" for sealing joints in fire-resistance-rated construction.
   2. Section 088000 "Glazing" for glazing sealants.
   3. Section 092900 "Gypsum Board" for acoustical sealing of perimeter joints.
   4. Section 093000 "Tiling" for sealing tile joints.

1.3 PRECONSTRUCTION TESTING

A. Preconstruction Compatibility and Adhesion Testing: Submit to joint-sealant manufacturers, for testing indicated below, samples of materials that will contact or affect joint sealants.
   1. Use ASTM C 1087 to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.
   2. Submit not fewer than eight pieces of each kind of material, including joint substrates, shims, joint-sealant backings, secondary seals, and miscellaneous materials.
   3. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
   4. For materials failing tests, obtain joint-sealant manufacturer's written instructions for corrective measures including use of specially formulated primers.
   5. Testing will not be required if joint-sealant manufacturers submit joint preparation data that are based on previous testing, not older than 24 months, of sealant products for adhesion to, and compatibility with, joint substrates and other materials matching those submitted.

B. Preconstruction Field-Adhesion Testing: Before installing sealants, field test their adhesion to Project joint substrates as follows:
   1. Locate test joints where indicated on Project or, if not indicated, as directed by Architect.
   2. Conduct field tests for each application indicated below:
      a. Each kind of sealant and joint substrate indicated.
   3. Notify Architect seven days in advance of dates and times when test joints will be erected.
   4. Arrange for tests to take place with joint-sealant manufacturer's technical representative present.
   1) For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.

5. Report whether sealant failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. For sealants that fail adhesively, retest until satisfactory adhesion is obtained.

6. Evaluation of Preconstruction Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing, in absence of other indications of noncompliance with requirements, will be considered satisfactory. Do not use sealants that fail to adhere to joint substrates during testing.

1.4 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 070413.

B. Product Data: For each joint-sealant product indicated.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Samples for Initial Selection: Manufacturer's color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.

E. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch wide joints formed between two 6-inch long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

F. Joint-Sealant Schedule: Include the following information:
   1. Joint-sealant application, joint location, and designation.
   2. Joint-sealant manufacturer and product name.

1.5 INFORMATIONAL SUBMITTALS

A. Preconstruction Compatibility and Adhesion Test Reports: From sealant manufacturer, indicating the following:
   1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with joint sealants.
   2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

B. Preconstruction Field-Adhesion Test Reports: Indicate which sealants and joint preparation methods resulted in optimum adhesion to joint substrates based on testing specified in "Preconstruction Testing" Article.

C. Field-Adhesion Test Reports: For each sealant application tested.
1.6 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Source Limitations: Obtain each kind of joint sealant from single source from single manufacturer.

C. Product Testing: Test joint sealants using a qualified testing agency.
   1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated.
   2. Test according to SWRI's Sealant Validation Program for compliance with requirements specified by reference to ASTM C 920 for adhesion and cohesion under cyclic movement, adhesion-in-peel, and indentation hardness.

D. Provide the following upon request:
   1. Qualification Data: For qualified Installer and testing agency.
   2. Product Certificates: For each kind of joint sealant and accessory, from manufacturer.
   3. Sealant, Waterproofing, and Restoration Institute (SWRI) Validation Certificate: For each sealant specified to be validated by SWRI's Sealant Validation Program.
   4. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, indicating that sealants comply with requirements.

E. Mockups: Install sealant in mockups of assemblies specified in other Sections that are indicated to receive joint sealants specified in this Section. Use materials and installation methods specified in this Section.

1.7 PROJECT CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:
   1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer[ or are below 40 deg F].
   2. When joint substrates are wet.
   3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
   4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

1.8 WARRANTY

A. Special Installer's Warranty: Manufacturer's standard form in which Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

B. Special Manufacturer's Warranty: Manufacturer's standard form in which joint-sealant manufacturer agrees to furnish joint sealants to repair or replace those that do not comply with performance and other requirements specified in this Section within specified warranty period.
   1. Warranty Period: Two years from date of Substantial Completion.

C. Special warranties specified in this article exclude deterioration or failure of joint sealants from the following:
1. Movement of the structure caused by structural settlement or errors attributable to design or construction resulting in stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression.
2. Disintegration of joint substrates from natural causes exceeding design specifications.
3. Mechanical damage caused by individuals, tools, or other outside agents.
4. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

B. VOC Content of Interior Sealants: Sealants and sealant primers used inside the weatherproofing system shall comply with the following limits for VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
   1. Architectural Sealants: 250 g/L.
   2. Sealant Primers for Nonporous Substrates: 250 g/L.
   3. Sealant Primers for Porous Substrates: 775 g/L.

C. Liquid-Applied Joint Sealants: Comply with ASTM C 920 and other requirements indicated for each liquid-applied joint sealant specified, including those referencing ASTM C 920 classifications for type, grade, class, and uses related to exposure and joint substrates.
   1. Suitability for Immersion in Liquids. Where sealants are indicated for Use I for joints that will be continuously immersed in liquids, provide products that have undergone testing according to ASTM C 1247. Liquid used for testing sealants is deionized water, unless otherwise indicated.

D. Stain-Test-Response Characteristics: Where sealants are specified to be nonstaining to porous substrates, provide products that have undergone testing according to ASTM C 1248 and have not stained porous joint substrates indicated for Project.

E. Suitability for Contact with Food: Where sealants are indicated for joints that will come in repeated contact with food, provide products that comply with 21 CFR 177.2600.

F. Colors of Exposed Joint Sealants: [As indicated by manufacturer's designations] [Match Architect's samples] [As selected by Architect from manufacturer's full range].

2.2 SILICONE JOINT SEALANTS

A. Sealant JS-51 - Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 50, for Use NT.
   1. Products: Subject to compliance with requirements, provide products from the following table that has a validation certificate from the Sealant, Waterproofing and Restoration Institute (SWRI).
## JOINT SEALANTS

### Substrate Primer Required:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Product</th>
<th>Manufacturer Rated Movement Capability (CLASS)</th>
<th>Mortar *</th>
<th>Anod. Alum.</th>
<th>Uncoated Glass</th>
<th>Other*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dow Corning</td>
<td>791</td>
<td>± 50%</td>
<td>Yes</td>
<td>Test</td>
<td>No</td>
<td>Test</td>
</tr>
<tr>
<td>Dow Corning</td>
<td>795</td>
<td>± 50%</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Test</td>
</tr>
<tr>
<td>Momentive Performance Materials, Inc.</td>
<td>Silpruf SCS2000</td>
<td>± 50%</td>
<td>Yes</td>
<td>Test</td>
<td>No</td>
<td>Test</td>
</tr>
<tr>
<td>Momentive Performance Materials, Inc.</td>
<td>Silpruf NB SCS 9000</td>
<td>± 50%</td>
<td>Yes</td>
<td>Test</td>
<td>No</td>
<td>Test</td>
</tr>
<tr>
<td>Pecora Corporation</td>
<td>864</td>
<td>± 50%</td>
<td>Yes</td>
<td>Test</td>
<td>No</td>
<td>Test</td>
</tr>
<tr>
<td>Pecora Corporation</td>
<td>895</td>
<td>± 50%</td>
<td>Yes</td>
<td>Test</td>
<td>No</td>
<td>Test</td>
</tr>
<tr>
<td>Tremco Incorporated</td>
<td>Spectrum 3</td>
<td>± 50%</td>
<td>Yes</td>
<td>Test</td>
<td>No</td>
<td>Test</td>
</tr>
<tr>
<td>Tremco Incorporated</td>
<td>Dymonic 100</td>
<td>± 50%</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Test</td>
</tr>
</tbody>
</table>

### Table Notes:

* Indicates substrates with a cement component, such as concrete, that require use of a primer.

** Indicates that other substrates shall be tested for adhesion to determine if a primer will be required.

### B. Sealant JS-S2 - Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant:

- **ASTM C 920, Type S, Grade NS, Class 100/50, for Use NT.**

  1. **Products:** Subject to compliance with requirements, provide products from the following table that has a validation certificate from the Sealant, Waterproofing and Restoration Institute (SWRI).

### Substrate Primer Required:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Product</th>
<th>Manufacturer Rated Movement Capability (CLASS)</th>
<th>Mortar *</th>
<th>Anod. Alum.</th>
<th>Uncoated Glass</th>
<th>Other*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dow Corning</td>
<td>790</td>
<td>+ 100/- 50%</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Test</td>
</tr>
<tr>
<td>Momentive Performance Materials, Inc.</td>
<td>Silpruf LM SCS2700</td>
<td>+ 100/- 50%</td>
<td>Yes</td>
<td>Test</td>
<td>No</td>
<td>Test</td>
</tr>
<tr>
<td>Pecora Corporation</td>
<td>890</td>
<td>+ 100/- 50%</td>
<td>Yes</td>
<td>Test</td>
<td>No</td>
<td>Test</td>
</tr>
</tbody>
</table>
JOINT SEALANTS

Substrate Primer Required:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Product</th>
<th>Manufacturer Rated Movement Capability (CLASS)</th>
<th>Mortar*</th>
<th>Anod.</th>
<th>Uncoated</th>
<th>Other*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tremco Incorporated</td>
<td>Spectrum 1</td>
<td>+ 100/- 50%</td>
<td>Yes</td>
<td>Test</td>
<td>No</td>
<td>Test</td>
</tr>
</tbody>
</table>

Table Notes:

* Indicates substrates with a cement component, such as concrete, that require use of a primer.

** Indicates that other substrates shall be tested for adhesion to determine if a primer will be required.

2.3 WEATHER BARRIER SEALANTS

A. Sealant JS-W1 - Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT; tested and marketed specifically for sealing air barrier and vapor retarder sheets to common building materials, such as aluminum, vinyl, PVC, powder coat, paint and fluoropolymer coatings; UV resistant.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Dow Corning Corporation; 758.

2.4 URETHANE JOINT SEALANTS

A. Sealant JS-U1 - Multicomponent, Pourable, Traffic-Grade, Urethane Joint Sealant: ASTM C 920. Type M, Grade P, Class 25, for Use T and I.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. LymTal International, Inc.; Iso-Flex 880 GB.
   b. May National Associates, Inc.; Bondaflex PUR 2 SL.
   c. Tremco Incorporated; Vulkem 445SSL or Vulkem 45SSL.

B. Sealant JS-U2 - Multicomponent, Nonsag, Traffic-Grade, Urethane Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use T.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. BASF Building Systems; MasterSeal NP 2.
   b. Pecora Corporation; Dynatred.
   c. Sika Corporation, Construction Products Division; Sikaflex - 2c NS.
   d. Tremco Incorporated; Vulkem 227.

2.5 LATEX JOINT SEALANTS

A. Sealant JS-L1 - Latex Joint Sealant: Acrylic latex or siliconized acrylic latex, ASTM C 834.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. BASF Building Systems; Sonolac.
c. Pecora Corporation; AC-20 + Silicone.
d. Tremco Incorporated; Tremflex 834.

2.6 MILDEW-RESISTANT JOINT SEALANTS

A. Sealant JS-M1 - Mildew-Resistant, Single-Component, Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. BASF Building Systems; Omniplus.
   b. Dow Corning Corporation; 786 Mildew Resistant.
   c. GE Advanced Materials - Silicones; Sanitary SCS1700.
   d. Pecora Corporation; 898.
   e. Tremco Incorporated; Tremsil 200 Sanitary.

2.7 ACOUSTICAL JOINT SEALANTS

A. Sealant JS-A1 - Acoustical Joint Sealant: Manufacturer's standard nonsag, paintable, nonstaining latex sealant complying with ASTM C 834. Product effectively reduces airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Accumetric LLC; BOSS 826 Acoustical Sound Sealant.
   b. GE Construction Sealants; RCS20 Acousticsl.
   c. Grabber Construction Products; Acoustical Sealant GSC.
   d. Pecora Corporation; AC-20 FTR or AIS-919.
   e. Tremco, Incorporated; Tremco Acoustical Sealant.
   f. USG Corporation; SHEETROCK Acoustical Sealant.

2.8 PREFORMED JOINT SEALANTS

A. Sealant JS-P1 - Preformed Silicone Joint Sealants: Manufacturer's standard sealant consisting of precured low-modulus silicone extrusion, in sizes to fit joint widths indicated, combined with a neutral-curing silicone sealant for bonding extrusions to substrates.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Dow Corning Corporation; 123 Silicone Seal.
   b. GE Construction Sealants; UltraSpan US1100.
   c. Pecora Corporation; Sil-Span.
   d. Tremco Incorporated; Spectrem Simple Seal.

2.9 JOINT SEALANT BACKING

A. General: Provide sealant backings of material that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
B. Cylindrical Sealant Backings: ASTM C 1330, Type C (closed-cell material with a surface skin) Type O (open-cell material) Type B (bicellular material with a surface skin) or any of the preceding types, as approved in writing by joint-sealant manufacturer for joint application indicated, and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.

C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.

2.10 MISCELLANEOUS MATERIALS

A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.

C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:
   1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
   2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
      a. Concrete.
      b. Masonry.
      c. Unglazed surfaces of ceramic tile.
      d. Exterior insulation and finish systems.
3. Remove laitance and form-release agents from concrete.
4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:
   a. Metal.
   b. Glass.
   c. Porcelain enamel.
   d. Glazed surfaces of ceramic tile.

B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Do not extend exterior sealants and primers into building interior (that is, inside the weatherproofing system) unless first verifying compliance with VOC requirements.

D. Install sealant backings of kind indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of sealant backings.
   2. Do not stretch, twist, puncture, or tear sealant backings.
   3. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.

E. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.

F. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
   1. Place sealants so they directly contact and fully wet joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

G. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
   1. Remove excess sealant from surfaces adjacent to joints.
2. Use tooling agents that are approved in writing by sealant manufacturer and that do not
discolor sealants or adjacent surfaces. Water-based tooling agents are unacceptable.
3. Provide concave joint profile per Figure 8A in ASTM C 1193, unless otherwise indicated.
4. Provide flush joint profile where indicated per Figure 8B in ASTM C 1193.
5. Provide recessed joint configuration of recess depth and at locations indicated per Figure 8C in ASTM C 1193.
   a. Use masking tape to protect surfaces adjacent to recessed tooled joints.

H. Installation of Preformed Silicone-Sealant System: Comply with the following requirements:
1. Apply masking tape to each side of joint, outside of area to be covered by sealant system.
2. Apply silicone sealant to each side of joint to produce a bead of size complying with preformed silicone-sealant system manufacturer's written instructions and covering a bonding area of not less than 3/8 inch. Hold edge of sealant bead 1/4 inch inside masking tape.
3. Within 10 minutes of sealant application, press silicone extrusion into sealant to wet extrusion and substrate. Use a roller to apply consistent pressure and ensure uniform contact between sealant and both extrusion and substrate.
4. Complete installation of sealant system in horizontal joints before installing in vertical joints. Lap vertical joints over horizontal joints. At ends of joints, cut silicone extrusion with a razor knife.

I. Installation of Preformed Foam Sealants: Install each length of sealant immediately after removing protective wrapping. Do not pull or stretch material. Produce seal continuity at ends, turns, and intersections of joints. For applications at low ambient temperatures, apply heat to sealant in compliance with sealant manufacturer's written instructions.

J. Acoustical Sealant Installation: At sound-rated assemblies and elsewhere as indicated, seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C 919, manufacturer's written recommendations, and section 092900 "Gypsum Board."

3.4 FIELD QUALITY CONTROL

A. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:
1. Extent of Testing: Test completed and cured sealant joints as follows:
   a. Perform 10 tests for the first 1000 feet of joint length for each kind of sealant and joint substrate.
   b. Perform 1 test for each 1000 feet of joint length thereafter or 1 test per each floor per elevation.
   a. For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
3. Inspect tested joints and report on the following:
   a. Whether sealants filled joint cavities and are free of voids.
   b. Whether sealant dimensions and configurations comply with specified requirements.
   c. Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. Compare these results to determine if adhesion passes sealant manufacturer's field-adhesion hand-pull test criteria.
4. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations, whether joints were primed, adhesion results and percent elongations, sealant fill, sealant configuration, and sealant dimensions.

5. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.

B. Evaluation of Field-Adhesion Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.

3.5 CLEANING

A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.6 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

3.7 JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Exterior joints in horizontal traffic surfaces; Type JS-U1.

1. Joint Locations:
   a. Isolation and contraction joints in cast-in-place concrete slabs.
   b. Other joints as indicated.

2. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.

B. Joint-Sealant Application: Exterior joints in vertical surfaces and horizontal nontraffic surfaces; Type JS-S1, JS-S2, or JS-P1.

1. Joint Locations:
   b. Joints between plaster edge material and adjacent materials.
   c. Architectural concrete units.
   d. Control and expansion joints in unit masonry.
   e. Joints between metal panels.
   f. Joints between different materials listed above.
   g. Perimeter joints between materials listed above and frames of doors, windows, and louvers.
   h. Control and expansion joints in ceilings and other overhead surfaces.
   i. Other joints as indicated.

2. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.
C. Joint-Sealant Application: Exterior weather barrier joints; Type JS-W1.

D. Joint-Sealant Application: Interior joints in horizontal traffic surfaces; Type JS-U1 JS-U2.
   1. Joint Locations:
      b. Control and expansion joints in tile flooring.
      c. Other joints as indicated.
   2. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.

E. Joint-Sealant Application: Interior joints in vertical surfaces and horizontal nontraffic surfaces; Type JS-L1.
   1. Joint Locations:
      a. Control and expansion joints on exposed interior surfaces of exterior walls.
      b. Perimeter joints of exterior openings where indicated.
      c. Wall tile control and expansion joints.
      d. Vertical joints on exposed surfaces of walls and partitions.
      e. Perimeter joints between interior wall surfaces and frames of interior doors, windows, and elevator entrances.
      f. Other joints as indicated.
   2. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.

F. Joint-Sealant Application: Mildew-resistant interior joints in vertical surfaces and horizontal nontraffic surfaces; Type JS-M1.
   1. Joint Location:
      a. Joints between plumbing fixtures and adjoining walls, floors, and counters.
      b. Tile control and expansion joints where indicated.
      c. Other joints as indicated.
   2. Joint-Sealant Color: As selected by Architect from manufacturer's full range of colors.


END OF SECTION
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes exterior building expansion joint cover and filler assemblies.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for expansion joint cover assemblies.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For each expansion joint cover assembly.
   1. Include plans, elevations, sections, details, splices, block-out requirement, attachments to other work, and line diagrams showing entire route of each expansion joint.
   2. Where expansion joint cover assemblies change planes, provide isometric or clearly detailed drawing depicting how components interconnect.

D. Samples: For each exposed expansion joint cover assembly and for each color and texture specified, full width by 6 inches long in size.

E. Certification: Manufacturer shall provide certification letter or test report confirming use of expansion joint cover and filler in NFPA 285 rated assembly.

F. Expansion Joint Cover Assembly Schedule: Prepared by or under the supervision of the supplier. Include the following information in tabular form:
   1. Manufacturer and model number for each expansion joint cover assembly.
   2. Expansion joint cover assembly location cross-referenced to Drawings.
   3. Nominal, minimum, and maximum joint width.
   4. Movement direction.
   5. Materials, colors, and finishes.
   6. Fire rating.
   7. Product options.

1.4 INFORMATIONAL SUBMITTALS

A. Certification: Manufacturer's certificate of compliance with NFPA 285 for each component.
B. Product Test Reports: For each fire-resistance-rated expansion joint cover assembly, for tests performed by manufacturer and witnessed by a qualified testing agency or by a qualified testing agency.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Approved by manufacturer and having experience installing joint systems that are similar in design complexity.

B. Source Limitations: Obtain all architectural joint systems through one source from a single manufacturer.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of architectural joint systems and are based on the specific systems indicated. Refer to Division 01 Section "Product Requirements."
   1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.

D. Fire-Test-Response Characteristics: Where indicated, provide architectural joint system and fire-barrier assemblies identical to those of assemblies tested for fire resistance per UL 2079 and/or ASTM E 1966 by a testing and inspecting agency acceptable to authorities having jurisdiction. Fire rating not less than the rating of adjacent construction.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of expansion joint cover and filler systems that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures including rupturing, cracking, or puncturing.
      b. Deterioration of metals, seals and other materials beyond normal weathering.
   2. Warranty Period: [Five] <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Furnish units in longest practicable lengths to minimize field splicing.

B. Include factory-fabricated closure materials and transition pieces, T-joints, corners, curbs, cross-connections, and other accessories as required to provide continuous expansion joint cover assemblies.

C. Miters and changes in direction may be field fabricated.
2.2 GENERAL PERFORMANCE REQUIREMENTS

A. Seismic Performance: Expansion joint cover assemblies shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Expansion Joint Design Criteria:
   1. Type of Movement: Thermal.
      a. Nominal Joint Width: As indicated on Drawings.
   2. Type of Movement: Seismic.
      a. Joint Movement: 100 percent.

2.3 EXTERIOR EXPANSION JOINT COVERS

A. Exterior Elastomeric-Seal Joint Cover: Assembly consisting of accordion-shaped elastomeric seal anchored to surface-mounted frames fixed to sides of joint gap.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Model SC-300 as manufactured by Construction Specialties, Inc., or comparable product by one of the following:
      a. Balco, Inc.
      b. InPro Corporation (IPC).
      c. Nystrom, Inc.
   2. Application: Wall to wall/corner.
   3. Installation: Recessed.
   4. Primary Seal: Preformed elastomeric membrane or extrusion set in metal frame.
      a. Color: As selected by Architect from manufacturer's full range.
   5. Secondary Seal: Manufacturer's standard extruded-elastomeric seal designed to prevent water and moisture infiltration.
   6. Fire Barrier: Provide 2-hour rated fire barrier.

B. Pre-Compressed-Seal Joint Filler: Precompressed fire-retardant-impregnated foam with both sides faced with waterproof silicone seal.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Model 2VFR-300 as manufactured by Construction Specialties, Inc., or comparable product by one of the following:
      a. Balco, Inc.
      b. InPro Corporation (IPC).
      c. Nystrom, Inc.
   2. Application: Wall to wall/corner.
   3. Installation: Recessed.
   5. Seal: Silicone.
      a. Color: As selected by Architect from manufacturer's full range.

2.4 PLAZA DECK EXPANSION JOINT COVERS

A. Metal-Plate Parking Deck Joint Cover: Assembly consisting of metal cover plate in continuous contact with metal frames fixed to sides of joint gap.
1. **Basis-of-Design Product:** Subject to compliance with requirements, provide Model PTS as manufactured by Nystrom, Inc. or comparable product by one of the following:
   a. Balco, Inc.
   b. Construction Specialties, Inc.
   c. InPro Corporation (IPC).

2. Application: Slab to slab.
3. Joint Width: As indicated.
4. Installation: Recessed block out.
5. Load Capacity:
   a. Uniform Load: 200 lb/sq. ft.
   c. Maximum Deflection: 0.125 inch.
6. Fire-Resistance Rating: Not less than that indicated on Drawings.
7. Cover-Plate Design: Plain.
8. Exposed Metal:
   a. Aluminum: Manufacturer's standard.

### 2.5 MATERIALS

   1. Finish: Class II, Clear Anodic Finish: AA-M12C22A31 (Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.

B. **Elastomeric Seals:** Manufacturer’s standard preformed elastomeric membranes or extrusions to be installed in metal frames.

C. **Compression Seals:** ASTM D2000; preformed rectangular elastomeric extrusions having internal baffle system and designed to function under compression.

D. **Fire Barriers:** Any material or material combination, when fire tested after cycling, designated to resist the passage of flame and hot gases through a movement joint and to meet performance criteria for required rating period.

E. **Moisture Barrier:** Manufacturer’s standard, flexible elastomeric material.

### 2.6 ACCESSORIES

A. **Moisture Barriers:** Manufacturer’s standard continuous, waterproof membrane within joint and attached to substrate on sides of joint.
   1. Provide where indicated on Drawings.

B. **Manufacturer’s standard attachment devices.** Include anchors, clips, fasteners, set screws, spacers, and other accessories compatible with material in contact, as indicated or required for complete installations.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces where expansion joint cover assemblies will be installed for installation tolerances and other conditions affecting performance of the Work.

B. Notify Architect where discrepancies occur that will affect proper expansion joint cover assembly installation and performance.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrates according to expansion joint cover assembly manufacturer's written instructions.

B. Coordinate and furnish anchorages, setting drawings, and instructions for installing expansion joint cover assemblies. Provide fasteners of metal, type, and size to suit type of construction indicated and to provide for secure attachment of expansion joint cover assemblies.

3.3 INSTALLATION

A. Comply with manufacturer's written instructions for storing, handling, and installing expansion joint cover assemblies and materials unless more stringent requirements are indicated.

B. Metal Frames: Perform cutting, drilling, and fitting required to install expansion joint cover assemblies.
   1. Install in true alignment and proper relationship to joints and adjoining finished surfaces measured from established lines and levels.
   2. Adjust for differences between actual structural gap and nominal design gap due to ambient temperature at time of installation.
   3. Cut and fit ends to accommodate thermal expansion and contraction of metal without buckling of frames.
   4. Install frames in continuous contact with adjacent surfaces.
      a. Shimming is not permitted.
   5. Locate anchors at interval recommended by manufacturer, but not less than 3 inches from each end and not more than 24 inches o.c.

C. Seals: Install elastomeric seals and membranes in frames to comply with manufacturer's written instructions. Install with minimum number of end joints.
   1. Provide in continuous lengths for straight sections.
   2. Seal transitions. Vulcanize or heat-weld field-spliced joints as recommended by manufacturer.
   3. Installation: Mechanically lock seals into frames or adhere to frames with adhesive or pressure-sensitive tape as recommended by manufacturer.

D. Compression Seals: Apply adhesive or lubricant adhesive as recommended by manufacturer before installing compression seals.
E. Install with hairline mitered corners where expansion joint cover assemblies change direction or abut other materials.

F. Terminate exposed ends of expansion joint cover assemblies with field- or factory-fabricated termination devices.

G. Fire-Resistance-Rated Assemblies: Coordinate installation of architectural joint assembly materials and associated work so complete assemblies comply with assembly performance requirements.
   1. Fire Barriers: Install fire barriers to provide continuous, uninterrupted fire resistance throughout length of joint, including transitions and field splices.

H. Water Barriers: Provide water barrier at exterior joints. Provide drainage fittings where indicated.

3.4 PROTECTION

A. Do not remove protective covering until finish work in adjacent areas is complete. When protective covering is removed, clean exposed metal surfaces to comply with manufacturer's written instructions.

B. Protect the installation from damage by work of other Sections.

END OF SECTION
SECTION 080413 - COMMON SUBMITTAL REQUIREMENTS FOR OPENINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
   a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Refer to Section 01330 for quantity of days allowed for review.
2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project’s environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER’S AND GENERAL CONTRACTOR’S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect’s staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:

   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.

   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.

   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.

1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.

1. Submittal Numbering: See below.
2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition

1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.
3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).
4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering
1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 081113 - HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes hollow-metal work.

B. Related Requirements:
   1. Section 081416 "Flush Wood Doors" for wood doors installed in hollow-metal frames.
   2. Section 083473.13 "Metal Sound Control Door Assemblies" for packaged, acoustical hollow-metal door and frame assemblies with STC ratings of 35 or more.
   3. Section 087100 "Door Hardware" for door hardware for hollow-metal doors.
   4. Section 099600 "High-Performance Coatings" for epoxy coatings on hollow metal doors and frames.

1.3 DEFINITIONS

A. Minimum Thickness: Minimum thickness of base metal without coatings according to NAAMM-HMMA 803 or SDI A250.8.

1.4 COORDINATION

A. Coordinate anchorage installation for hollow-metal frames. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, core descriptions, fire-resistance ratings, temperature-rise ratings, and finishes.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Include the following:
   1. Elevations of each door type.
   2. Details of doors, including vertical- and horizontal-edge details and metal thicknesses.
   3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
   4. Locations of reinforcement and preparations for hardware.
   5. Details of each different wall opening condition.
   6. Details of anchorages, joints, field splices, and connections.
7. Details of accessories.
8. Details of moldings, removable stops, and glazing.
9. Details of conduit and preparations for power, signal, and control systems.

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Samples for Verification:
1. For each type of exposed finish required, prepared on Samples of not less than 3 by 5 inches.
2. For "Doors" and "Frames" subparagraphs below, prepare Samples approximately 8 by 10 inches to demonstrate compliance with requirements for quality of materials and construction:
   a. Doors: Show vertical-edge, top, and bottom construction; core construction; and hinge and other applied hardware reinforcement. Include separate section showing glazing if applicable.
   b. Frames: Show profile, corner joint, floor and wall anchors, and silencers. Include separate section showing fixed hollow-metal panels and glazing if applicable.

F. Schedule: Provide a schedule of hollow-metal work prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with final Door Hardware Schedule.

1.6 QUALITY ASSURANCE

A. Provide the following upon request.
1. Product Test Reports: For each type of hollow-metal door and frame assembly, for tests performed by a qualified testing agency.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver hollow-metal work palletized, packaged, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.

B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.

C. Store hollow-metal work vertically under cover at Project site with head up. Place on minimum 4-inch high wood blocking. Provide minimum 1/4-inch space between each stacked door to permit air circulation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Amweld International, LLC.
2. Ceco Door; ASSA ABLOY.
3. Curries Company; ASSA ABLOY.
4. Door Components, Inc.
5. Steelcraft; an Allegion brand.

B. Source Limitations: Obtain hollow-metal work from single source from single manufacturer.

2.2 REGULATORY REQUIREMENTS

A. Fire-Rated Assemblies: Complying with NFPA 80 and listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252 or UL 10C.
   1. Smoke- and Draft-Control Assemblies: Provide an assembly with gaskets listed and labeled for smoke and draft control by a qualified testing agency acceptable to authorities having jurisdiction, based on testing according to UL 1784 and installed in compliance with NFPA 105.

B. Fire-Rated, Borrowed-Lite Assemblies: Complying with NFPA 80 and listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction for fire-protection ratings indicated, based on testing according to NFPA 257 or UL 9.

2.3 INTERIOR DOORS AND FRAMES

A. Construct interior doors and frames to comply with the standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.

B. Heavy-Duty Doors: SDI A250.8, Level 2.
   1. Physical Performance: Level B according to SDI A250.4.
   2. Doors:
      a. Type: As indicated in the Door Schedule.
      c. Face: Uncoated, cold-rolled steel sheet, minimum thickness of 0.042 inch.
      d. Edge Construction: Model 2, Seamless.
      e. Core: Manufacturer's standard kraft-paper honeycomb, polystyrene, polyurethane, polysiocyanurate, mineral-board, or vertical steel-stiffener core at manufacturer's discretion.
      f. Locations: Typical, except as indicated.
   3. Exposed Finish: Primed for field coating.

   1. Physical Performance: Level A according to SDI A250.4.
   2. Doors:
      a. Type: As indicated in the Door Schedule.
      c. Face: Uncoated, cold-rolled steel sheet, minimum thickness of 0.053 inch.
      d. Edge Construction: Model 2, Seamless.
      e. Core: Manufacturer's standard kraft-paper honeycomb, polystyrene, polyurethane, polysiocyanurate, mineral-board, or vertical steel-stiffener core at manufacturer's discretion.
      f. Locations: At hollow metal door locations in high traffic areas not indicated to be wood doors or otherwise indicated, and at mechanical equipment rooms.
3. Frames:
   a. Materials: Uncoated, steel sheet, minimum thickness of 0.053 inch.
   b. Sidelite Frames: Fabricated from same thickness material as adjacent door frame.
   c. Construction: Full profile welded.
   d. Locations: Typical.
4. Exposed Finish: Primed for field coating.

2.4 EXTERIOR HOLLOW-METAL DOORS AND FRAMES

A. Construct exterior doors and frames to comply with the standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.

   1. Physical Performance: Level A according to SDI A250.4.
   2. Doors:
      a. Type: As indicated in the Door Schedule.
      b. Thickness: 1-3/4 inches
      c. Face: Metallic-coated steel sheet, minimum thickness of 0.053 inch, with minimum A40 coating.
      d. Edge Construction: Model 2, Seamless.
      e. Core: Polyisocyanurate or Mineral board.
         1) Thermal-Rated Doors: Provide doors fabricated with thermal-resistance value (R-value) of not less than 2.1 deg F x h x sq. ft./Btu when tested according to ASTM C 1363.
   3. Frames:
      a. Materials: Metallic-coated steel sheet, minimum thickness of 0.053 inch, with minimum A40 coating.
      b. Construction: Full profile welded.
   4. Exposed Finish: Primed for field coating.

2.5 BORROWED LITES

A. Hollow-metal frames of uncoated steel sheet, minimum thickness of 0.053 inch.

B. Construction: Full profile welded.
   1. Exposed Finish: Primed for field coating.

2.6 FRAME ANCHORS

A. Jamb Anchors:
   1. Stud-Wall Type: Designed to engage stud, welded to back of frames; not less than 0.042 inch thick.

B. Floor Anchors: Formed from same material as frames, minimum thickness of 0.042 inch, and as follows:
   1. Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.
2. Separate Topping Concrete Slabs: Adjustable-type anchors with extension clips, allowing not less than 2-inch height adjustment. Terminate bottom of frames at finish floor surface.

2.7 MATERIALS

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B; suitable for exposed applications.

C. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.

D. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B.

E. Frame Anchors: ASTM A 879/A 879M, Commercial Steel (CS), 04Z coating designation; mill phosphatized.

1. For anchors built into exterior walls, steel sheet complying with ASTM A 1008/A 1008M or ASTM A 1011/A 1011M, hot-dip galvanized according to ASTM A 153/A 153M, Class B.

F. Inserts, Bolts, and Fasteners: Hot-dip galvanized according to ASTM A 153/A 153M.

G. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hollow-metal frames of type indicated.

H. Grout: ASTM C 476, except with a maximum slump of 4 inches, as measured according to ASTM C 143/C 143M.

I. Mineral-Fiber Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers manufactured from slag or rock wool; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; passing ASTM E 136 for combustion characteristics.

J. Glazing: Comply with requirements in Section 088000 "Glazing."

K. Bituminous Coating: Cold-applied asphalt mastic, compounded for 15-mil dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

2.8 FABRICATION

A. Fabricate hollow-metal work to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for metal thickness. Where practical, fit and assemble units in manufacturer's plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.

B. Hollow-Metal Doors:
1. Steel-Stiffened Door Cores: Provide minimum thickness 0.026 inch, steel vertical stiffeners of same material as face sheets extending full-door height, with vertical webs spaced not more than 6 inches apart. Spot weld to face sheets no more than 5 inches o.c. Fill spaces between stiffeners with glass- or mineral-fiber insulation.

2. Fire Door Cores: As required to provide fire-protection[ and temperature-rise] ratings indicated.


4. Top Edge Closures: Close top edges of doors with flush closures of same material as face sheets.

5. Bottom Edge Closures: Close bottom edges of doors with end closures or channels of same material as face sheets.

6. Exterior Doors: Provide weep-hole openings in bottoms of exterior doors to permit moisture to escape. Seal joints in top edges of doors against water penetration.

7. Astragals: Provide overlapping astragal on one leaf of pairs of doors where required by NFPA 80 for fire-performance rating or where indicated. Extend minimum 3/4 inch beyond edge of door on which astragal is mounted or as required to comply with published listing of qualified testing agency.

C. Hollow-Metal Frames: Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated of same thickness metal as frames.

1. Sidelite Frames: Provide closed tubular members with no visible face seams or joints, fabricated from same material as door frame. Fasten members at crossings and to jambs by butt welding.

2. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.

3. Grout Guards: Weld guards to frame at back of hardware mortises in frames to be grouted.

4. Floor Anchors: Weld anchors to bottoms of jambs with at least four spot welds per anchor; however, for slip-on drywall frames, provide anchor clips or countersunk holes at bottoms of jambs.

5. Jamb Anchors: Provide number and spacing of anchors as follows:
   a. Stud-Wall Type: Locate anchors not more than 18 inches from top and bottom of frame. Space anchors not more than 32 inches o.c. and as follows:
      1) Four anchors per jamb from 60 to 90 inches high.
      2) Five anchors per jamb from 90 to 96 inches high.
   b. Compression Type: Not less than two anchors in each frame.
   c. Postinstalled Expansion Type: Locate anchors not more than 6 inches from top and bottom of frame. Space anchors not more than 26 inches o.c.

6. Head Anchors: Two anchors per head for frames more than 42 inches wide and mounted in metal-stud partitions.

7. Door Silencers: Except on weather-stripped frames, drill stops to receive door silencers as follows. Keep holes clear during construction.
   a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
   b. Double-Door Frames: Drill stop in head jamb to receive two door silencers.

8. Terminated Stops: Terminate stops 6 inches above finish floor with a 45-degree angle cut, and close open end of stop with steel sheet closure. Cover opening in extension of frame with welded-steel filler plate, with welds ground smooth and flush with frame.

D. Fabricate concealed stiffeners and edge channels from either cold- or hot-rolled steel sheet.
E. Hardware Preparation: Factory prepare hollow-metal work to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping according to SDI A250.6, the Door Hardware Schedule, and templates.

1. Reinforce doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.
2. Comply with applicable requirements in SDI A250.6 and BHMA A156.115 for preparation of hollow-metal work for hardware.

F. Stops and Moldings: Provide stops and moldings around glazed lites and louvers where indicated. Form corners of stops and moldings with [butted] [or] [mitered] hairline joints.

1. Single Glazed Lites: Provide fixed stops and moldings welded on secure side of hollow-metal work.
2. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames.
3. Provide loose stops and moldings on inside of hollow-metal work.
4. Coordinate rabbet width between fixed and removable stops with glazing and installation types indicated.

2.9 STEEL FINISHES

A. Prime Finish: Clean, pretreat, and apply manufacturer's standard primer.

1. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with SDI A250.10; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

B. Field-Applied Finish: Finish hollow metal doors and frames in accordance with Section 099600 “High-performance Coatings.”

1. Color and Gloss: As selected by Architect from manufacturer's full range.

2.10 ACCESSORIES

A. Louvers: Provide louvers for interior doors, where indicated, which comply with SDI 111C, with blades or baffles formed of 0.020-inch- thick, cold-rolled steel sheet set into 0.032-inch- thick steel frame.

1. Sightproof Louver: Stationary louvers constructed with inverted-V or inverted-Y blades.

B. Mullions and Transom Bars: Join to adjacent members by welding or rigid mechanical anchors.

C. Grout Guards: Formed from same material as frames, not less than 0.016 inch thick.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for embedded and built-in anchors to verify actual locations before frame installation.
C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces.

B. Drill and tap doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.

3.3 INSTALLATION

A. General: Install hollow-metal work plumb, rigid, properly aligned, and securely fastened in place. Comply with Drawings and manufacturer’s written instructions.

B. Hollow-Metal Frames: Install hollow-metal frames for doors, transoms, sidelites, borrowed lites, and other openings, of size and profile indicated. Comply with SDI A250.11 or NAAMM-HMMA 840 as required by standards specified.

1. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.
   a. At fire-rated openings, install frames according to NFPA 80.
   b. Where frames are fabricated in sections because of shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces.
   c. Install frames with removable stops located on secure side of opening.
   d. Install door silencers in frames before grouting.
   e. Remove temporary braces necessary for installation only after frames have been properly set and secured.
   f. Check plumb, square, and twist of frames as walls are constructed. Shim as necessary to comply with installation tolerances.
   g. Field apply bituminous coating to backs of frames that will be filled with grout containing antifreezing agents.

2. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, and secure with postinstalled expansion anchors.
   a. Floor anchors may be set with power-actuated fasteners instead of postinstalled expansion anchors if so indicated and approved on Shop Drawings.


4. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout.

5. Concrete Walls: Solidly fill space between frames and concrete with mineral-fiber insulation.

6. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.

7. In-Place Metal or Wood-Stud Partitions: Secure slip-on drywall frames in place according to manufacturer’s written instructions.
8. **Installation Tolerances:** Adjust hollow-metal door frames for squareness, alignment, twist, and plumb to the following tolerances:
   a. **Squareness:** Plus or minus 1/16 inch, measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
   b. **Alignment:** Plus or minus 1/16 inch, measured at jambs on a horizontal line parallel to plane of wall.
   c. **Twist:** Plus or minus 1/16 inch, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
   d. **Plumbness:** Plus or minus 1/16 inch, measured at jambs at floor.

C. **Hollow-Metal Doors:** Fit hollow-metal doors accurately in frames, within clearances specified below. Shim as necessary.
   1. **Non-Fire-Rated Steel Doors:**
      a. Between Door and Frame Jambs and Head: 1/8 inch plus or minus 1/32 inch.
      b. Between Edges of Pairs of Doors: 1/8 inch to 1/4 inch plus or minus 1/32 inch.
      c. At Bottom of Door: [3/4 inch] [5/8 inch] plus or minus 1/32 inch.
      d. Between Door Face and Stop: 1/16 inch to 1/8 inch plus or minus 1/32 inch.
   2. **Fire-Rated Doors:** Install doors with clearances according to NFPA 80.
   3. **Smoke-Control Doors:** Install doors and gaskets according to NFPA 105.

D. **Glazing:** Comply with installation requirements in Section 088000 "Glazing" and with hollow-metal manufacturer's written instructions.
   1. Secure stops with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches o.c. and not more than 2 inches o.c. from each corner.

### 3.4 ADJUSTING AND CLEANING

A. **Final Adjustments:** Check and readjust operating hardware items immediately before final inspection. Leave work in complete and proper operating condition. Remove and replace defective work, including hollow-metal work that is warped, bowed, or otherwise unacceptable.

B. **Remove grout and other bonding material from hollow-metal work immediately after installation.**

C. **Prime-Coat Touchup:** Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.

D. **Metallic-Coated Surface Touchup:** Clean abraded areas and repair with galvanizing repair paint according to manufacturer's written instructions.

E. **Touchup Painting:** Cleaning and touchup painting of abraded areas of paint are specified in painting Sections.

END OF SECTION
SECTION 081416 - FLUSH WOOD DOORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Solid-core doors with wood-veneer and plastic-laminate faces.
   2. Factory finishing flush wood doors.
   3. Factory fitting flush wood doors to frames and factory machining for hardware.

B. Related Requirements:
   1. Section 081113 "Hollow-Metal Doors and Frames" for frames in which to install wood doors.
   2. Section 088000 "Glazing" for glass view panels in flush wood doors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of door. Include details of core and edge construction[, louvers,] and trim for openings. Include factory-finishing specifications.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Indicate location, size, and hand of each door; elevation of each kind of door; construction details not covered in Product Data; and the following:
   1. Dimensions and locations of blocking.
   2. Dimensions and locations of mortises and holes for hardware.
   3. Dimensions and locations of cutouts.
   4. Undercuts.
   5. Requirements for veneer matching.
   6. Doors to be factory finished and finish requirements.
   7. Fire-protection ratings for fire-rated doors.

D. Samples for Verification:
   1. Factory finishes applied to actual door face materials, approximately 8 by 10 inches, for each material and finish. For each wood species and transparent finish, provide set of three Samples showing typical range of color and grain to be expected in finished Work.
   2. Corner sections of doors, approximately 8 by 10 inches, with door faces and edges representing actual materials to be used.
      a. Provide Samples for each species of veneer and solid lumber required.
      b. Finish veneer-faced door Samples with same materials proposed for factory-finished doors.
   3. Frames for light openings, 6 inches long, for each material, type, and finish required.
1.4 INFORMATIONAL SUBMITTALS
A. Quality Standard Compliance Certificates: AWI Quality Certification or WI Certified Compliance Program certificates.

1.5 QUALITY ASSURANCE
A. Manufacturer Qualifications: A qualified manufacturer that is certified for chain of custody by an FSC-accredited certification body and is a certified participant in AWI's Quality Certification Program or is a licensee of WI's Certified Compliance Program.
B. Vendor Qualifications: A vendor that is certified for chain of custody by an FSC-accredited certification body.

1.6 DELIVERY, STORAGE, AND HANDLING
A. Comply with requirements of referenced standard and manufacturer's written instructions.
B. Package doors individually in cardboard cartons and wrap bundles of doors in plastic sheeting.
C. Mark each door ontop and bottom rail with opening number used on Shop Drawings.

1.7 FIELD CONDITIONS
A. Environmental Limitations: Do not deliver or install doors until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and HVAC system is operating and maintaining temperature between 60 and 90 deg F and relative humidity between 43 and 70 percent during remainder of construction period.

1.8 WARRANTY
A. Special Warranty: Manufacturer agrees to repair or replace doors that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
   a. Warping (bow, cup, or twist) more than 1/4 inch in a 42-by-84-inch section.
   b. Telegraphing of core construction in face veneers exceeding 0.01 inch in a 3-inch span.
2. Warranty shall also include installation and finishing that may be required due to repair or replacement of defective doors.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Ampco.
2. Eggers Industries.
3. Graham Wood Doors; an Assa Abloy Group company.
5. VT Industries, Inc.

B. Source Limitations: Obtain flush wood doors from single manufacturer.

2.2 FLUSH WOOD DOORS, GENERAL

A. Quality Standard: In addition to requirements specified, comply with AWI's, AWMAC's, and WI's "Architectural Woodwork Standards."
   1. Provide AWI Quality Certification or WI Certified Compliance Labels indicating that doors comply with requirements of grades specified.
   2. Contract Documents contain selections chosen from options in quality standard and additional requirements beyond those of quality standard. Comply with those selections and requirements in addition to quality standard.

B. Regional Materials: Flush wood doors shall be manufactured within 100 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

C. Certified Wood: Flush wood doors shall be certified as "FSC Pure" or "FSC Mixed Credit" according to FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship," and to FSC STD-40-004, "FSC Standard for Chain of Custody Certification."

D. Low-Emitting Materials: Fabricate doors with adhesives and composite wood products that do not contain urea formaldehyde.

E. WDMA I.S.1-A Performance Grade:
   1. Heavy Duty unless otherwise indicated.
   2. Extra Heavy Duty: Classrooms, public toilets, janitor's closets and exits, unless indicated to be hollow metal.

F. Fire-Rated Wood Doors: Doors complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252.
   1. Temperature-Rise Limit: At vertical exit enclosures and exit passageways, provide doors that have a maximum transmitted temperature end point of not more than 450 deg F (250 deg C) above ambient after 30 minutes of standard fire-test exposure.
   2. Cores: Provide core specified or mineral core as needed to provide fire-protection rating indicated.
   3. Edge Construction: Provide edge construction with intumescent seals concealed by outer stile. Comply with specified requirements for exposed edges.
   4. Pairs: Provide fire-retardant stiles that are listed and labeled for applications indicated without formed-steel edges and astragals. Provide stiles with concealed intumescent seals. Comply with specified requirements for exposed edges.
   5. Pairs: Provide formed-steel edges and astragals with intumescent seals.
      a. Finish steel edges and astragals with baked enamel same color as doors.
      b. Finish steel edges and astragals to match door hardware (locksets or exit devices).
G. Smoke- and Draft-Control Door Assemblies: Listed and labeled for smoke and draft control, based on testing according to UL 1784.

H. Particleboard-Core Doors:
1. Particleboard: ANSI A208.1, Grade LD-2, made with binder containing no urea-formaldehyde.
2. Particleboard: Straw-based particleboard complying with ANSI A208.1, Grade LD-2 or M-2, except for density.
3. Blocking: Provide wood blocking in particleboard-core doors as needed to eliminate through-bolting hardware.
4. Provide doors with structural-composite-lumber cores instead of particleboard cores for doors indicated to receive exit devices.

I. Structural-Composite-Lumber-Core Doors:
   a. Screw Withdrawal, Face: 700 lbf.
   b. Screw Withdrawal, Edge: 400 lbf.

J. Mineral-Core Doors:
1. Core: Noncombustible mineral product complying with requirements of referenced quality standard and testing and inspecting agency for fire-protection rating indicated.
2. Blocking: Provide composite blocking with improved screw-holding capability approved for use in doors of fire-protection ratings indicated as needed to eliminate through-bolting hardware.
3. Edge Construction: At hinge stiles, provide laminated-edge construction with improved screw-holding capability and split resistance. Comply with specified requirements for exposed edges.

2.3 VENEER-FACED DOORS FOR TRANSPARENT FINISH

A. Interior Solid-Core Doors:
1. Grade: Premium, with Grade A faces.
2. Species and Cut: Match Architect's Samples.
4. Assembly of Veneer Leaves on Door Faces: Center-balance match.
5. Pair and Set Match: Provide for doors hung in same opening or separated only by mullions.
6. Room Match: Provide door faces of compatible color and grain within each separate room or area of building.
7. Exposed Vertical and Top Edges: Applied wood-veneer edges of same species as faces and covering edges of faces - edge Type B.
8. Core: Particleboard, except for through-bolt locations.
9. Construction: Five or seven plies. Stiles and rails are bonded to core, then entire unit is abrasive planed before veneering. Faces are bonded to core using a hot press.

2.4 LIGHT FRAMES AND LOUVERS

A. Wood Beads for Light Openings in Wood Doors: Provide manufacturer's standard wood beads unless otherwise indicated.
FLUSH WOOD DOORS

1. Wood Species: Species compatible with door faces.
2. Profile: Recessed tapered beads.
3. At wood-core doors with 20-minute fire-protection ratings, provide wood beads and metal glazing clips approved for such use.

B. Wood-Veneered Beads for Light Openings in Fire-Rated Doors: Manufacturer's standard wood-veneer noncombustible beads matching veneer species of door faces and approved for use in doors of fire-protection rating indicated. Include concealed metal glazing clips where required for opening size and fire-protection rating indicated.

2.5 FABRICATION

A. Factory fit doors to suit frame-opening sizes indicated. Comply with clearance requirements of referenced quality standard for fitting unless otherwise indicated.
   1. Comply with NFPA 80 requirements for fire-rated doors.

B. Factory machine doors for hardware that is not surface applied. Locate hardware to comply with DHI-WDHS-3. Comply with final hardware schedules, door frame Shop Drawings, BHMA-156.115-W, and hardware templates.
   1. Coordinate with hardware mortises in metal frames to verify dimensions and alignment before factory machining.
   2. Metal Astragals: Factory machine astragals and formed-steel edges for hardware for pairs of fire-rated doors.

C. Transom and Side Panels: Fabricate matching panels with same construction, exposed surfaces, and finish as specified for associated doors. Finish bottom edges of transoms and top edges of rabbeted doors same as door stiles.
   1. Fabricate door and transom panels with full-width, solid-lumber[, rabbeted,] meeting rails. Provide factory-installed spring bolts for concealed attachment into jambs of metal door frames.

D. Openings: Factory cut and trim openings through doors.
   1. Light Openings: Trim openings with moldings of material and profile indicated.
   2. Glazing: Factory install glazing in doors indicated to be factory finished. Comply with applicable requirements in Section 088000 "Glazing."

2.6 SHOP PRIMING

A. Doors for Transparent Finish: Shop prime faces and all four edges with stain (if required), other required pretreatments, and first coat of finish as specified in Section 099300 "Staining and Transparent Finishing." Seal edges of cutouts and mortises with first coat of finish.

2.7 FACTORY FINISHING

A. General: Comply with referenced quality standard for factory finishing. Complete fabrication, including fitting doors for openings and machining for hardware that is not surface applied, before finishing.
   1. Finish faces, all four edges, edges of cutouts, and mortises. Stains and fillers may be omitted on top and bottom edges, edges of cutouts, and mortises.
B. Factory finish doors that are indicated to receive transparent finish.

C. Transparent Finish:
   1. Grade: Premium.
   2. Finish: AWI's, AWMAC's, and WI's "Architectural Woodwork Standards" System 9, UV curable, acrylated epoxy, polyester, or urethane.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine doors and installed door frames, with Installer present, before hanging doors.
   1. Verify that installed frames comply with indicated requirements for type, size, location, and swing characteristics and have been installed with level heads and plumb jambs.
   2. Reject doors with defects.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Hardware: For installation, see Section 087100 "Door Hardware." Installation Instructions: Install doors to comply with manufacturer's written instructions and referenced quality standard, and as indicated.
   1. Install fire-rated doors according to NFPA 80.
   2. Install smoke- and draft-control doors according to NFPA 105.

B. Job-Fitted Doors: Align and fit doors in frames with uniform clearances and bevels as indicated below; do not trim stiles and rails in excess of limits set by manufacturer or permitted for fire-rated doors. Machine doors for hardware. Seal edges of doors, edges of cutouts, and mortises after fitting and machining.
   1. Clearances: Provide 1/8 inch at heads, jambs, and between pairs of doors. Provide 1/8 inch from bottom of door to top of decorative floor finish or covering unless otherwise indicated. Where threshold is shown or scheduled, provide 1/4 inch from bottom of door to top of threshold unless otherwise indicated.
      a. Comply with NFPA 80 for fire-rated doors.
      b. 2. Bevel non-fire-rated doors 1/8 inch in 2 inches at lock and hinge edges.

C. Factory-Fitted Doors: Align in frames for uniform clearance at each edge.

D. Factory-Finished Doors: Restore finish before installation if fitting or machining is required at Project site.

3.3 ADJUSTING

A. Operation: Rehang or replace doors that do not swing or operate freely.
B. Finished Doors: Replace doors that are damaged or that do not comply with requirements. Doors may be repaired or refinished if Work complies with requirements and shows no evidence of repair or refinishing.

END OF SECTION
SECTION 083113 - ACCESS DOORS AND FRAMES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes access doors and frames for walls and ceilings.
   B. Related Requirements:
      1. Section 077200 "Roof Accessories" for roof hatches.
      2. Division 23 Section for "Air Duct Accessories" for heating and air-conditioning duct access doors.

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of product.
      1. Include construction details, fire ratings, material descriptions, dimensions of individual components and profiles, and finishes.
   B. Sustainable Design Submittals required by Section 01813 applicable to this Section.
   C. Samples: For each type of access door and frame and for each finish specified, complete assembly minimum 6 by 6 inches in size.
   D. Product Schedule: For access doors and frames.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
   A. Fire-Rated Access Doors and Frames: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection[ and temperature-rise limit] ratings indicated, according to NFPA 252 or UL 10B.

2.2 ACCESS DOORS AND FRAMES
   A. Recessed Access Doors with Concealed Flanges:
      1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
         a. Babcock-Davis.
b. JL Industries, Inc.; a division of the Activar Construction Products Group.


d. Larsens Manufacturing Company.

e. Nystrom, Inc.

f. Williams Bros. Corporation of America (The).

2. Description: Door face recessed 5/8 inch for gypsum board infill; with concealed flange for gypsum board installation and concealed hinge.

3. Locations: Wall.

4. Door Size: Minimal, as indicated or required to access device or fixture.

5. Uncoated Steel Sheet for Door: Nominal 0.060 inch, 16 gage, factory primed paint-ready. Typical, except as indicated.

6. Metallic-Coated Steel Sheet for Door: Nominal 0.064 inch, 16 gage, factory primed paint-ready. Use at wet areas.

7. Latch and Lock: Cam latch, screwdriver operated.

B. Drop-in Ceiling Access Panels and Frames:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Lift & Shift Access Panels as manufactured by IntexForms, Inc., or comparable by one of the following:

   a. Castle Access Panels and Forms, Inc.
   
   b. Nystrom, Inc.
   
   c. Wind-Lock Stealth Access Panels

2. Description: Glass fiber reinforced gypsum drop-in/pop-up panel, 1/2 inch or 5/8 inch deep for ceiling access to match gypsum board.

3. Locations: Non-rated gypsum board ceilings.

4. Door Size: Minimal, as indicated or required to access device or fixture.

5. Shape: Radius corner.


7. Flange: Drywall bead.


C. Exterior Flush Access Doors:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Babcock-Davis.
   
   b. JL Industries, Inc.; a division of the Activar Construction Products Group.
   
   
   d. Larsens Manufacturing Company.
   
   e. Nystrom, Inc.
   
   f. Williams Bros. Corporation of America (The).

2. Description: Weatherproof assembly, with face of door fit flush with frame and with exposed frame. Include extruded door gaskets and minimum 2-inch-thick fiberglass insulation. At plaster ceilings, use recessed type with concealed hinges, for application of plaster infill.

3. Locations: Wall and soffit.

4. Door Size: Minimal, as indicated or required to access device or fixture.

5. Metallic-Coated Steel Sheet for Door: Nominal 0.064 inch, 16 gage, factory primed paint-ready.

6. Frame Material: Same material, thickness, and finish as door.

7. Latch and Lock: Cam latch operated by handle, with keyed lock in handle.
2.3 **FIRE-RATED ACCESS DOORS AND FRAMES**

A. **Fire-Rated, Flush Access Doors with Concealed Flanges:**
   1. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Babcock-Davis.
      b. JL Industries, Inc.; a division of the Activar Construction Products Group.
      d. Nystrom, Inc.
      e. Williams Bros. Corporation of America (The).
   2. **Description:** Door face flush with frame, with a core of mineral-fiber insulation enclosed in sheet metal; with concealed flange for gypsum board installation, self-closing door, and concealed hinge.
   3. **Locations:** Wall and ceiling.
   4. **Door Size:** Minimal, as indicated or required to access device or fixture.
   5. **Fire-Resistance Rating:** Not less than that of adjacent construction.
   6. **Temperature-Rise Rating:** If required in exit enclosures, 450 deg F at the end of 30 minutes.
   7. **Uncoated Steel Sheet for Door:** Nominal 0.036 inch, 20 gage, factory primed paint-ready.
   8. **Frame Material:** Same material, thickness, and finish as door.
   9. **Latch and Lock:** Self-closing, self-latching door hardware, screw-driver operated.

2.4 **MATERIALS**

A. **Steel Plates, Shapes, and Bars:** ASTM A 36/A 36M.

B. **Steel Sheet:** Uncoated or electrolytic zinc coated, ASTM A 879/A 879M, with cold-rolled steel sheet substrate complying with ASTM A 1008/A 1008M, Commercial Steel (CS), exposed.

C. **Metallic-Coated Steel Sheet:** ASTM A 653/A 653M, Commercial Steel (CS), Type B; with minimum G60 or A60 metallic coating.

D. **Frame Anchors:** Same material as door face.

E. **Inserts, Bolts, and Anchor Fasteners:** Hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329.

2.5 **FABRICATION**

A. **General:** Provide access door and frame assemblies manufactured as integral units ready for installation.

B. **Metal Surfaces:** For metal surfaces exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

C. **Doors and Frames:** Grind exposed welds smooth and flush with adjacent surfaces. Furnish mounting holes, attachment devices and fasteners of type required to secure access doors to types of supports indicated.
1. For concealed flanges with drywall bead, provide edge trim for gypsum panels securely attached to perimeter of frames.
2. For concealed flanges with plaster bead for full-bed plaster applications, provide zinc-coated expanded-metal lath and exposed casing bead welded to perimeter of frames.

D. Recessed Access Doors: Form face of panel to provide recess for application of applied finish. Reinforce panel as required to prevent buckling. Provide access sleeves for each latch operator and install in holes cut through finish.

1. For recessed doors with plaster infill, provide self-furring expanded-metal lath attached to door panel.

E. Latch and Lock Hardware:

1. Quantity: Furnish number of latches and locks required to hold doors tightly closed.
2. Keys: Furnish two keys per lock and key all locks alike.

2.6 FINISHES

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

D. Painted Finishes: Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

1. Factory Primed: Apply manufacturer's standard, lead- and chromate-free, universal primer immediately after surface preparation and pretreatment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's written instructions for installing access doors and frames.
3.3 ADJUSTING
A. Adjust doors and hardware, after installation, for proper operation.

END OF SECTION
SECTION 083473.13 - METAL SOUND CONTROL DOOR ASSEMBLIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes metal sound control door assemblies.

1.3 COORDINATION

A. Coordinate installation of anchorages for sound control door assemblies. Furnish setting drawings, templates, and directions for installing anchorages. Deliver sleeves, inserts, anchor bolts, and items with integral anchors to Project site in time for installation.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include sound ratings, construction details, material descriptions, core descriptions, fire-resistance rating, and finishes.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For sound control door assemblies.
   1. Include elevations of each door design.
   2. Include details of sound control seals, door bottoms, and thresholds.
   3. Include details of doors, including vertical- and horizontal-edge details and metal thicknesses.
   4. Include frame details for each frame type, including dimensioned profiles and metal thicknesses.
   5. Include locations of reinforcements and preparations for hardware.
   6. Include details of each different wall opening condition.
   7. Include details of anchorages, joints, field splices, and connections.
   8. Include details of accessories.
   9. Include details of conduits and preparations for power, signal, and control systems.

D. Samples for Verification: For each type of exposed finish not less than 3 by 5 inches
   1. Doors and Frames: Samples approximately 12 by 12 inches
      a. Doors: Include section of vertical-edge, top, and bottom construction; automatic door bottom or gasket; core construction; [glazing; ]and hinge and other applied hardware reinforcement.
      b. Frames: Include profile, corner joint, floor and wall anchors, and seals.

E. Schedule: Provide a schedule of sound control door assemblies prepared using same reference numbers for details and openings as those on Drawings. Coordinate with the Door Hardware Schedule.
1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For sound control door assemblies to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Provide the following upon request:
   1. Qualification Data: For Installer.
   2. Product Certificates: For each type of sound control door assembly.
   3. Product Test Reports: For each sound control door assembly, for tests performed by manufacturer and witnessed by a qualified testing agency or performed by a qualified testing agency.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver doors and frames palletized, wrapped, or crated to provide protection during transit and Project-site storage. Avoid the use of nonvented plastic.
   1. Provide additional protection to prevent damage to factory-finished units.

B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.

C. Store doors and frames vertically under cover at Project site with head up. Place on minimum 4-inch-high wood blocking. Provide minimum 1/4-inch space between each stacked door to permit air circulation.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of sound control door assemblies that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Failure to meet sound rating requirements.
      b. Faulty operation of sound seals.
      c. Deterioration of metals, metal finishes, and other materials beyond normal use or weathering.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Sound Rating: Provide sound control door assemblies identical to those of assemblies tested as sound-retardant units by an acoustical testing agency, and have the following minimum rating:
1. STC Rating: Not less than 45 as calculated by ASTM E 413 when tested in an operable condition according to ASTM E 90.

B. Fire-Rated Assemblies: Complying with NFPA 80 and listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252 or UL 10C.
   1. Smoke- and Draft Control Assemblies: Provide an assembly with gaskets listed and labeled for smoke and draft control by a qualified testing agency acceptable to authorities having jurisdiction, based on testing according to UL 1784 and installed in compliance with NFPA 105.

2.2 STEEL SOUND CONTROL DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ambico Limited.
   2. Amweld International, LLC.
   4. Overly Door Company.

B. Source Limitations: Obtain steel sound control door assemblies, including doors, frames, sound control seals, hinges, thresholds, and other items essential for sound control, from single source from single manufacturer.

C. Doors: Flush-design sound control doors, thickness as required to provide STC rating, of seamless construction; with manufacturer's standard sound-retardant core as required to provide STC and fire rating indicated. Construct doors with smooth, flush surfaces without visible joints or seams on exposed faces or stile edges. Fabricate according to NAAMM-HMMA 865.
   1. Interior Doors: Fabricate from cold-rolled steel sheet unless otherwise indicated, 0.048-inch nominal thickness or thicker as required to achieve STC rating indicated.
   2. Core: Manufacturer's standard sound control core.
   3. Top and Bottom Channels: Closed with continuous channels of same material as face sheets, spot welded to face sheets not more than 6 inches o.c.
   4. Hardware Reinforcement: Same material as face sheets.

D. Materials:
   1. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B, suitable for exposed applications.

E. Finishes:
   1. Prime Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating.
      a. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with SDI A250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.
2.3 SOUND CONTROL FRAMES

A. Frames: Fabricate sound control door frames with corners mitered, reinforced, and continuously welded the full depth and width of frame. Fabricate according to NAAMM-HMMA 865.
   1. Weld frames according to NAAMM-HMMA 820.
   2. Interior Frames: Fabricate from cold-rolled steel sheet unless otherwise indicated, 0.075-inch nominal thickness or thicker as required to provide STC rating indicated.
   3. Hardware Reinforcement: Fabricate according to NAAMM-HMMA 865 of same material as face sheets.
   4. Head Reinforcement: Metallic-coated steel channel or angle stiffener, 0.108-inch nominal thickness.
   5. Jamb Anchors:
      a. Stud-Wall Type: Designed to engage stud, welded to back of frames; not less than 0.048-inch nominal-thickness uncoated steel unless otherwise indicated.
   6. Floor Anchors: Not less than 0.079-inch nominal-thickness metallic-coated steel, and as follows:
      a. Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners.

B. Materials:
   1. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B, suitable for exposed applications.
   2. Supports and Anchors: After fabricating, galvanize units to be built into exterior walls according to ASTM A 153/A 153M, Class B.
   3. Inserts, Bolts, and Fasteners: Provide items to be built into exterior walls, hot-dip galvanized according to ASTM A 153/A 153M or ASTM F 2329.
   4. Powder-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching sound control door frames of type indicated.

C. Finishes:
   1. Prime Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating.
      a. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with SDI A250.10 acceptance criteria; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

2.4 HARDWARE

A. Sound Control Door Hardware: Manufacturer's standard sound control system, including head and jamb seals, door bottoms, cam-lift hinges, and thresholds, as required by testing to achieve STC and fire rating indicated.
   1. Head and Jamb Seals: One of the following:
a. Neoprene Compression Seals: One-piece units consisting of closed-cell sponge neoprene seal held in place by metal retainer, with retainer cover of same material as door frame; attached to door frame with concealed screws.
b. Silicone Compression Seals: One-piece units consisting of silicone compression bulb and stabilizer flange; attached to door frame adhesively.
c. Magnetic Seals: One-piece units consisting of closed-cell sponge neoprene seal and resiliently mounted magnet held in place by metal retainer, with retainer cover of same material as door frame; attached to door frame with concealed screws.

2. Automatic Door Bottoms: Neoprene or silicone gasket, held in place by metal housing, that automatically drops to form seal when door is closed; mounted to bottom edge of door with screws.
   a. Mounting: Mortised or semimortised into bottom of door as required by testing to achieve STC rating indicated.

3. Cam-Lift Hinges: Full-mortise template type that raises door 1/2 inch when door is fully open; with hardened pin; fabricated from stainless steel.
4. Thresholds: Flat, smooth, unfluted type as recommended by manufacturer; fabricated from aluminum.
   a. Finish: Clear anodic finish.

2.5 FABRICATION

A. Steel Sound Control Door Fabrication: Sound control doors to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal.
   1. Comply with requirements in NFPA 80 for fire-rated and smoke control doors.
   2. Seamless Edge Construction: Fabricate doors with faces joined at vertical edges by welding; welds shall be ground, filled, and dressed to make them invisible and to provide a smooth, flush surface.
   3. Hardware Preparation: Factory prepare sound control doors to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping.
      a. Reinforce doors to receive nontemplated mortised and surface-mounted door hardware.
      b. Locate door hardware as indicated, or if not indicated, according to NAAMM-HMMA 831, "Recommended Hardware Locations for Custom Hollow Metal Doors and Frames."
   4. Tolerances: Fabricate doors to tolerances indicated in NAAMM-HMMA 865.

B. Sound Control Frame Fabrication: Fabricate sound control frames to be rigid and free of defects, warp, or buckle. Accurately form metal to required sizes and profiles, with minimum radius for thickness of metal. Where practical, fit and assemble units in manufacturer's plant. To ensure proper assembly at Project site, clearly identify work that cannot be permanently factory assembled before shipment.
   1. Weld flush face joints continuously; grind, fill, dress, and make smooth, flush, and invisible. Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated from same thickness metal as frames.
   2. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
   3. Floor Anchors: Weld anchors to bottom of jambs and mullions with at least four spot welds per anchor.
   4. Jamb Anchors: Provide number and spacing of anchors as follows:
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces.

B. Prior to installation, adjust and securely brace sound control door frames to the following tolerances:
   1. Squareness: Plus or minus 1/16 inch, measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
   2. Alignment: Plus or minus 1/16 inch, measured at jambs on a horizontal line parallel to plane of wall.
   3. Twist: Plus or minus 1/16 inch, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
   4. Plumbness: Plus or minus 1/16 inch, measured at jambs on a perpendicular line from head to floor.

C. Drill and tap doors and frames to receive nontemplated mortised and surface-mounted door hardware.
3.3 INSTALLATION

A. General: Install sound control door assemblies plumb, rigid, properly aligned, and securely fastened in place; comply with manufacturer's written instructions.

B. Frames: Install sound control door frames in sizes and profiles indicated.
   1. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces, leaving surfaces smooth and undamaged.
      a. At fire-rated openings, install frames according to NFPA 80.
      b. At openings requiring smoke and draft control, install frames according to NFPA 105.
      c. Where frames are fabricated in sections due to shipping or handling limitations, field splice at approved locations by welding face joint continuously; grind, fill, and dress; make splice smooth, flush, and invisible on exposed faces.
      d. Remove temporary braces only after frames or bucks have been properly set and secured.
      e. Check squareness, twist, and plumbness of frames as walls are constructed. Shim as necessary to comply with installation tolerances.

   2. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, and secure with postinstalled expansion anchors.


   4. Ceiling Struts: Extend struts vertically from top of frame at each jamb to supporting construction above unless frame is anchored to masonry or to other structural support at each jamb. Bend top of struts to provide flush contact for securing to supporting construction above. Provide adjustable wedged or bolted anchorage to frame jamb members.

   5. Installation Tolerances: Adjust sound control door frames for squareness, alignment, twist, and plumbness to the following tolerances:
      a. Squareness: Plus or minus 1/16 inch, measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
      b. Alignment: Plus or minus 1/16 inch, measured at jambs on a horizontal line parallel to plane of wall.
      c. Twist: Plus or minus 1/16 inch, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
      d. Plumbness: Plus or minus 1/16 inch, measured at jambs on a perpendicular line from head to floor.

C. Doors: Fit sound control doors accurately in frames, within clearances indicated below. Shim as necessary.
   1. Non-Fire-Rated Doors: Fit non-fire-rated doors accurately in frames with the following clearances:
      b. Head with Butt Hinges: 1/8 inch.
      c. Head with Cam-Lift Hinges: As required by manufacturer, but not more than 3/8 inch.
      d. Sill: Manufacturer’s standard.
      e. Between Edges of Pairs of Doors: 1/8 inch.

   2. Fire-Rated Doors: Install fire-rated doors with clearances according to NFPA 80.

D. Sound Control Seals: Where seals have been factory prefit and preinstalled and subsequently removed for shipping, reinstall seals and adjust according to manufacturer’s written instructions.
E. Cam-Lift Hinges: Install hinges according to manufacturer's written instructions.

F. Thresholds: Set thresholds in full bed of sealant complying with requirements in Section 079200 "Joint Sealants."

3.4 ADJUSTING AND CLEANING

A. Final Adjustments: Check and adjust seals, door bottoms, and other sound control hardware items right before final inspection. Leave work in complete and proper operating condition.

B. Remove and replace defective work, including defective or damaged sound seals and doors and frames that are warped, bowed, or otherwise unacceptable.
   1. Adjust gaskets, gasket retainers, and retainer covers to provide contact required to achieve STC rating.

C. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible, rust-inhibitive, air-drying primer.

END OF SECTION
SECTION 084113 - ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Storefront framing for punched openings.
   2. Exterior manual-swing entrance doors and door-frame units.

B. Related Requirements:
   1. Section 084216 "Interior Aluminum Storefront Frames" for interior storefront/officefront aluminum frames.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Conference shall be held at least two weeks prior to fabrication and/or installation of storefront system. Arrange meeting at Project site with the glazier, sealant, and gasket manufacturers’ technical representatives and any others necessary to review procedures, products to be used, and schedule for the Work. Give at least two weeks notice to Architect and other concerned parties.

1.4 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 080413.

B. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Shop Drawings: For aluminum-framed entrances and storefronts. Include plans, elevations, sections, full-size details, and attachments to other work.
   1. Include details of provisions for assembly expansion and contraction and for draining moisture occurring within the assembly to the exterior.
   2. Include full-size isometric details of each vertical-to-horizontal intersection of aluminum-framed entrances and storefronts, showing the following:
      a. Joinery, including concealed welds.
b. Anchorage.
c. Expansion provisions.
d. Glazing.
e. Flashing and drainage.

3. Show connection to and continuity with adjacent thermal, weather, air, and vapor barriers.

E. Samples for Verification: For each type of exposed finish required, in manufacturer's standard sizes.

F. Fabrication Sample: Of each vertical-to-horizontal intersection of assemblies, made from 12-inch lengths of full-size components and showing details of the following:
   1. Joinery, including concealed welds.
   2. Expansion provisions.
   4. Flashing and drainage.

G. Entrance Door Hardware Schedule: Prepared by or under supervision of supplier, detailing fabrication and assembly of entrance door hardware, as well as procedures and diagrams. Coordinate final entrance door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of entrance door hardware.

H. Delegated-Design Submittal: For aluminum-framed entrances and storefronts indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For aluminum-framed entrances and storefronts to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Product Options: Information on Drawings and in Specifications establishes requirements for aesthetic effects and performance characteristics of assemblies. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction.
   1. Do not change intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If changes are proposed, submit comprehensive explanatory data to Architect for review.

C. Provide the following upon request:
   1. Qualification Data: For Installer.
   2. Energy Performance Certificates: For aluminum-framed entrances and storefronts, accessories, and components, from manufacturer.
      a. Basis for Certification: NFRC-certified energy performance values for each aluminum-framed entrance and storefront.
3. Product Test Reports: For aluminum-framed entrances and storefronts, for tests performed by manufacturer and witnessed by a qualified testing agency or by a qualified testing agency.

4. Field quality-control reports.

1.7 MOCKUPS

A. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.

1. Build mockup of typical wall area as shown on Drawings.
2. Testing shall be performed on mockups according to requirements in "Field Quality Control" Article.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of aluminum-framed entrances and storefronts that do not comply with requirements or that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures including, but not limited to, excessive deflection.
   b. Noise or vibration created by wind and thermal and structural movements.
   c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
   d. Water penetration through fixed glazing and framing areas.
   e. Failure of operating components.

2. Warranty Period: Five years from date of Substantial Completion.

B. Special Finish Warranty: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of factory-applied finishes within specified warranty period.

1. Deterioration includes, but is not limited to, the following:
   a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
   b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
   c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design aluminum-framed entrances and storefronts.
B. General Performance: Comply with performance requirements specified, as determined by testing of aluminum-framed entrances and storefronts representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.

1. Aluminum-framed entrances and storefronts shall withstand movements of supporting structure including, but not limited to, story drift, twist, column shortening, long-term creep, and deflection from uniformly distributed and concentrated live loads.

2. Failure also includes the following:
   a. Thermal stresses transferring to building structure.
   b. Glass breakage.
   c. Noise or vibration created by wind and thermal and structural movements.
   d. Loosening or weakening of fasteners, attachments, and other components.
   e. Failure of operating units.

C. Structural Loads:

1. Wind and Seismic Loads: As indicated on Drawings.

2. Other Design Loads: As indicated on Drawings.

D. Deflection of Framing Members: At design wind pressure, as follows:

1. Deflection Normal to Wall Plane: Limited to 1/175 of clear span for spans up to 13 feet 6 inches and to 1/240 of clear span plus 1/4 inch for spans greater than 13 feet 6 inches or an amount that restricts edge deflection of individual glazing lites to 3/4 inch, whichever is less.

2. Deflection Parallel to Glazing Plane: Limited to amount not exceeding that which reduces glazing bite to less than 75 percent of design dimension and that which reduces edge clearance between framing members and glazing or other fixed components to less than 1/8 inch.
   a. Operable Units: Provide a minimum 1/16-inch clearance between framing members and operable units.

3. Cantilever Deflection: Where framing members overhang an anchor point, as follows:
   a. Perpendicular to Plane of Wall: No greater than 1/240 of clear span plus 1/4 inch for spans greater than 11 feet 8-1/4 inches or 1/175 times span, for spans less than 11 feet 8-1/4 inches.

E. Structural: Test according to ASTM E 330 as follows:

1. When tested at positive and negative wind-load design pressures, assemblies do not evidence deflection exceeding specified limits.

2. When tested at 150 percent of positive and negative wind-load design pressures, assemblies, including anchorage, do not evidence material failures, structural distress, or permanent deformation of main framing members exceeding 0.2 percent of span.

3. Test Durations: As required by design wind velocity, but not less than 10 seconds.

F. Air Infiltration: Test according to ASTM E 283 for infiltration as follows:

1. Fixed Framing and Glass Area:
   a. Maximum air leakage of 0.06 cfm/sq. ft. (0.30 L/s per sq. m) at a static-air-pressure differential of 6.24 lbf/sq. ft.300 Pa.

2. Entrance Doors:
   a. Pair of Doors: Maximum air leakage of 1.0 cfm/sq. ft. at a static-air-pressure differential of 1.57 lbf/sq. ft.
   b. Single Doors: Maximum air leakage of 0.5 cfm/sq. ft. (2.54 L/s per sq. m) at a static-air-pressure differential of 1.57 lbf/sq. ft.
G. Water Penetration under Static Pressure: Test according to ASTM E 331 as follows:
   1. No evidence of water penetration through fixed glazing and framing areas when tested according to a minimum static-air-pressure differential of 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft. (300 Pa).

H. Water Penetration under Dynamic Pressure: Test according to AAMA 501.1 as follows:
   1. No evidence of water penetration through fixed glazing and framing areas when tested at dynamic pressure equal to 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft. (300 Pa).
   2. Maximum Water Leakage: No uncontrolled water penetrating assemblies or water appearing on assemblies' normally exposed interior surfaces from sources other than condensation. Water leakage does not include water controlled by flashing and gutters, or water that is drained to exterior.

I. Seismic Performance: Aluminum-framed entrances and storefronts shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

J. Energy Performance: Certify and label energy performance according to NFRC as follows:
   1. Thermal Transmittance (U-factor): Fixed glazing and framing areas shall have U-factor of not more than 0.45 Btu/sq. ft. x h x deg F as determined according to NFRC 100.
   2. Solar Heat Gain Coefficient: Fixed glazing and framing areas shall have a solar heat gain coefficient of no greater than 0.35 as determined according to NFRC 200.
   3. Condensation Resistance: Design the wall and its components to not develop any visible interior condensation on framing members or glazing when the exterior air dry bulb temperature is 35 degrees F and the interior air dry bulb temperature is 65 degrees F with a 45 percent relative humidity.

K. Thermal Movements: Allow for thermal movements resulting from ambient and surface temperature changes:
   1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.
   2. Thermal Cycling: No buckling; stress on glass; sealant failure; excess stress on framing, anchors, and fasteners; or reduction of performance when tested according to AAMA 501.5.
      a. High Exterior Ambient-Air Temperature: That which produces an exterior metal-surface temperature of 180 deg F.
      b. Low Exterior Ambient-Air Temperature: 0 deg F.
      c. Interior Ambient-Air Temperature: 75 deg F.

2.2 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide listed products as manufactured by Kawneer North America; an Alcoa company, or comparable product by one of the following:
   1. EFCO Corporation.
   2. Vistawall Architectural Products; Oldcastle BuildingEnvelope.

2.3 BASIS-OF-DESIGN PRODUCTS

A. Selected Products:
   1. Punched Window at Brick: Kawneer; TriFab 601UT; 2-inch by 6-inch.
2. Punched Window at Plaster: Kawneer; TriFab 451UT; 2-inch by 4-1/2-inch

B. Source Limitations: Obtain all components of aluminum-framed entrance and storefront system, including framing and accessories, from single manufacturer.

2.4 FRAMING

A. Framing Members: Manufacturer's extruded- or formed-aluminum framing members of thickness required and reinforced as required to support imposed loads.
   1. Construction: Thermally broken; sizes as indicated.
   2. Glazing System: Retained mechanically with gaskets on four sides.
   5. Fabrication Method: Field-fabricated stick system.

B. Backer Plates: Manufacturer's standard, continuous backer plates for framing members, if not integral, where framing abuts adjacent construction.

C. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

D. Materials:
   1. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
      a. Sheet and Plate: ASTM B 209.
      b. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221.
      c. Extruded Structural Pipe and Tubes: ASTM B 429/B 429M.
      d. Structural Profiles: ASTM B 308/B 308M.
   2. Steel Reinforcement: Manufacturer's standard zinc-rich, corrosion-resistant primer complying with SSPC-PS Guide No. 12.00; applied immediately after surface preparation and pretreatment. Select surface preparation methods according to recommendations in SSPC-SP COM, and prepare surfaces according to applicable SSPC standard.
      a. Structural Shapes, Plates, and Bars: ASTM A 36/A 36M.
      b. Cold-Rolled Sheet and Strip: ASTM A 1008/A 1008M.
      c. Hot-Rolled Sheet and Strip: ASTM A 1011/A 1011M.

2.5 INSULATED METAL PANELS

A. Insulated Metal Panels: Laminated, metal-faced flat panels with no deviations in plane exceeding 0.8 percent of panel dimension in width or length.
   1. Overall Panel Thickness: 1 inch.
   2. Exterior Skin: Aluminum.
      a. Thickness: Manufacturer's standard for finish and texture indicated.
      b. Finish: Match framing system.
      c. Texture: Smooth.
      d. Backing Sheet: 0.157-inch thick, cement board.
   3. Interior Skin: Aluminum.
      a. Thickness: Manufacturer's standard for finish and texture indicated.
      b. Finish: Low-gloss, white baked enamel.
      c. Texture: Smooth.
d. Backing Sheet: 1/2-inch-thick, gypsum board with proprietary fire-resistance-rated core.

4. Thermal Insulation Core: Manufacturer's standard rigid, closed-cell, polyisocyanurate board.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 450 or less.

2.6 ENTRANCE DOOR SYSTEMS

A. Entrance Doors: Manufacturer's standard glazed entrance doors for manual-swing operation.
   1. Door Construction: 1-3/4-inch overall thickness, with minimum 0.125-inch-thick, extruded-aluminum tubular rail and stile members. Mechanically fasten corners with reinforcing brackets that are deeply penetrated and fillet welded or that incorporate concealed tie rods.
      a. Thermal Construction: High-performance plastic connectors separate aluminum members exposed to the exterior from members exposed to the interior.
   2. Door Design: As indicated.
      a. Provide 10-inch bottom rail to comply with accessibility requirements.
      a. Provide nonremovable glazing stops on outside of door.

2.7 ENTRANCE DOOR HARDWARE

A. Entrance Door Hardware: Hardware not specified in this Section is specified in Section 087100 "Door Hardware."

B. General: Provide entrance door hardware and entrance door hardware sets indicated in door and frame schedule for each entrance door to comply with requirements in this Section.
   1. Entrance Door Hardware Sets: Provide quantity, item, size, finish or color indicated, and named manufacturers' products or products equivalent in function and comparable in quality to named products.
   2. Sequence of Operation: Provide electrified door hardware function, sequence of operation, and interface with other building control systems indicated.
   3. Opening-Force Requirements:
      a. Egress Doors: Not more than 15 lbf to release the latch and not more than 30 lbf to set the door in motion and not more than 15 lbf to open the door to its minimum required width.
      b. Accessible Interior Doors: Not more than 5 lbf to fully open door.

C. Cylinders: As specified in Section 087100 "Door Hardware."
   1. Keying: Master key system. Permanently inscribe each key with a visual key control number and include notation "DO NOT DUPLICATE".

D. Weather Stripping: Manufacturer's standard replaceable components.
1. Compression Type: Made of ASTM D 2000, molded neoprene, or ASTM D 2287, molded PVC.
2. Sliding Type: AAMA 701/702, made of wool, polypropylene, or nylon woven pile with nylon-fabric or aluminum-strip backing.

E. Thresholds: BHMA A156.21, raised thresholds beveled with a slope of not more than 1:2, with maximum height of 1/2 inch in accordance with CBC Title 24 Chapter 11B.

2.8 GLAZING

A. Glazing: Comply with Section 088000 "Glazing."

B. Glazing Gaskets: Manufacturer's standard sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers.

C. Glazing Sealants: As recommended by manufacturer.

D. Sealants used inside the weatherproofing system shall have a VOC content of 250 g/L.

E. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.9 ACCESSORIES

A. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.

1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.

2. Reinforce members as required to receive fastener threads.

B. Anchors: Three-way adjustable anchors with minimum adjustment of [1 inch] <Insert dimension> that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.

C. Concealed Flashing: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials or Dead-soft, 0.018-inch thick stainless steel, ASTM A 240/A 240M of type recommended by manufacturer.

D. Bituminous Paint: Cold-applied asphalt-mastic paint complying with SSPC-Paint 12 requirements except containing no asbestos, formulated for 30-mil thickness per coat.

2.10 FABRICATION

A. Form or extrude aluminum shapes before finishing.

B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.

C. Fabricate components that, when assembled, have the following characteristics:
1. Profiles that are sharp, straight, and free of defects or deformations.
2. Accurately fitted joints with ends cope or mitered.
3. Physical and thermal isolation of glazing from framing members.
4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
5. Provisions for field replacement of glazing from exterior.
6. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.

D. Mechanically Glazed Framing Members: Fabricate for flush glazing without projecting stops.

E. Storefront Framing: Fabricate components for assembly using shear-block system.

F. Entrance Door Frames: Reinforce as required to support loads imposed by door operation and for installing entrance door hardware.
   1. At exterior doors, provide compression weather stripping at fixed stops.

G. Entrance Doors: Reinforce doors as required for installing entrance door hardware.
   1. At pairs of exterior doors, provide sliding-type weather stripping retained in adjustable strip and mortised into door edge.
   2. At exterior doors, provide weather sweeps applied to door bottoms.

H. Entrance Door Hardware Installation: Factory install entrance door hardware to the greatest extent possible. Cut, drill, and tap for factory-installed entrance door hardware before applying finishes.

I. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.

2.11 ALUMINUM FINISHES

A. High-Performance Organic Finish: Three-coat fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
   1. Color and Gloss: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General:
1. Comply with manufacturer's written instructions.
2. Do not install damaged components.
3. Fit joints to produce hairline joints free of burrs and distortion.
4. Rigidly secure nonmovement joints.
5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
6. Seal perimeter and other joints watertight unless otherwise indicated.

B. Metal Protection:
   1. Where aluminum is in contact with dissimilar metals, protect against galvanic action by painting contact surfaces with materials recommended by manufacturer for this purpose or by installing nonconductive spacers.
   2. Where aluminum is in contact with concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

C. Set continuous sill members and flashing in full sealant bed as specified in Section 079200 "Joint Sealants" to produce weathertight installation.

D. Install components plumb and true in alignment with established lines and grades.

E. Install glazing as specified in Section 088000 "Glazing."

F. Entrance Doors: Install doors to produce smooth operation and tight fit at contact points.
   1. Exterior Doors: Install to produce weathertight enclosure and tight fit at weather stripping.
   2. Field-Installed Entrance Door Hardware: Install surface-mounted entrance door hardware according to entrance door hardware manufacturers' written instructions using concealed fasteners to greatest extent possible.

3.3 ERECTION TOLERANCES

A. Erection Tolerances: Install aluminum-framed entrances and storefronts to comply with the following maximum tolerances:
   1. Plumb: 1/8 inch in 10 feet; 1/4 inch in 40 feet.
   2. Level: 1/8 inch in 20 feet; 1/4 inch in 40 feet.
   3. Alignment:
      a. Where surfaces abut in line or are separated by reveal or protruding element up to 1/2 inch wide, limit offset from true alignment to 1/16 inch.
      b. Where surfaces are separated by reveal or protruding element from 1/2 to 1 inch wide, limit offset from true alignment to 1/8 inch.
      c. Where surfaces are separated by reveal or protruding element of 1 inch wide or more, limit offset from true alignment to 1/4 inch.
   4. Location: Limit variation from plane to 1/8 inch in 12 feet; 1/2 inch over total length.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Field Quality-Control Testing: Perform the following test on mockup and representative areas of aluminum-framed entrances and storefronts.
1. Water-Spray Test: Before installation of interior finishes has begun, areas designated by Architect shall be tested according to AAMA 501.2 and shall not evidence water penetration.
   a. Perform tests on 100 percent of punched openings, prior to 10, 35, and 70 percent completion and after 100 percent of installations are complete.

C. Aluminum-framed entrances and storefronts will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 CLEANING

A. Clean exposed frame surfaces promptly after installation, using cleaning methods recommended by frame manufacturer and according to AAMA 609 & 610.

B. Touch up marred frame surfaces so touchup is not visible from a distance of 48 inches. Remove and replace frames with damaged finish that cannot be satisfactorily repaired.

END OF SECTION
SECTION 084216 - INTERIOR ALUMINUM STOREFRONT FRAMES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes interior aluminum storefront frames for wood doors and glazing installed in gypsum board partitions.

B. Related Requirements:
   1. Section 081416 "Flush Wood Doors" for wood doors installed in interior aluminum frames.
   2. Section 088000 "Glazing" for glass installed in interior aluminum frames.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, fire-resistance rating, and finishes.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Include the following:
   1. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
   2. Locations of reinforcements and preparations for hardware.
   3. Details of each different wall-opening condition.
   4. Details of anchorages, joints, field splices, and connections.
   5. Details of accessories.
   6. Details of moldings, removable stops, and glazing.
   7. Details of conduits and preparations for power, signal, and control systems.

D. Samples for Verification: For interior aluminum frames, prepared on Samples; 12 inches long.

E. Schedule: For interior aluminum frames. Use same designations indicated on Drawings. Coordinate with door hardware schedule and glazing.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For interior aluminum frames to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Provide the following upon request:
1. **Product Test Reports:** Based on evaluation of comprehensive tests performed by a qualified testing agency, for each type of interior aluminum frame.

   B. **Mockups:** Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
      1. Build mockup of typical interior wall area as shown on Drawings.
      2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

   **1.6 DELIVERY, STORAGE, AND HANDLING**

      A. Deliver interior aluminum frames palletized, wrapped, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic. Store interior aluminum frames under cover at Project site.

   **1.7 WARRANTY**

      A. Special Warranty: Manufacturer agrees to repair or replace components of aluminum-framed entrances and storefronts that do not comply with requirements or that fail in materials or workmanship within specified warranty period.
      1. Failures include, but are not limited to, the following:
         a. Structural failures including, but not limited to, excessive deflection.
         b. Deterioration of metals, and other materials beyond normal weathering.
         c. Failure of operating components.
      2. Warranty Period: Five years from date of Substantial Completion.

      B. Special Finish Warranty: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of factory-applied finishes within specified warranty period.
      1. Deterioration includes, but is not limited to, the following:
         a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
         b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
         c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
      2. Warranty Period: 10 years from date of Substantial Completion.

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS**

   A. **Basis-of-Design Product:** Subject to compliance with requirements, provide TriFab 450 aluminum frames as manufactured by Kawneer North America; an Alcoa company, or comparable product by one of the following:
      1. EFCO Corporation.
      2. Oldcastle BuildingEnvelope.

   B. **Source Limitations:** Obtain all components of aluminum-framed storefront system, including framing and accessories, from single manufacturer.
2.2 COMPONENTS

A. Framing Members: Manufacturer's extruded- or formed-aluminum framing members of thickness required and reinforced as required to support imposed loads.
   1. Construction: Non-thermally broken; 2 inch by 4 inch framing member.
   2. Glazing System: Retained mechanically with gaskets on four sides.
   5. Fabrication Method: Field-fabricated stick system.

B. Backer Plates: Manufacturer's standard, continuous backer plates for framing members, if not integral, where framing abuts adjacent construction.

C. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

D. Materials:
   1. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
      a. Sheet and Plate: ASTM B 209.
      b. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221.
      c. Extruded Structural Pipe and Tubes: ASTM B 429/B 429M.
      d. Structural Profiles: ASTM B 308/B 308M.

E. Door Frames: Extruded aluminum to match adjacent frames, reinforced for hinges, strikes, and closers.

F. Glazing Frames: Extruded aluminum, for glazing thickness indicated.

G. Ceiling Tracks: Extruded aluminum.

H. Trim: Extruded aluminum, not less than 0.062 inch thick, with glazing stops and door stops without exposed fasteners.
   1. Trim Style: Square.

2.3 DOOR HARDWARE

A. Door Hardware: Hardware not specified in this Section is specified in Section 087100 "Door Hardware."

B. General: Provide door hardware and door hardware sets indicated in door and frame schedule for each entrance door to comply with requirements in this Section.
   1. Door Hardware Sets: Provide quantity, item, size, finish or color indicated, and named manufacturers' products or products equivalent in function and comparable in quality to named products.
   2. Sequence of Operation: Provide electrified door hardware function, sequence of operation, and interface with other building control systems indicated.
   3. Opening-Force Requirements:
      a. Egress Doors: Not more than 15 lbf to release the latch and not more than 30 lbf to set the door in motion and not more than 15 lbf to open the door to its minimum required width.
b. Accessible Interior Doors: Not more than 5 lbf to fully open door.

C. Cylinders: As specified in Section 087100 "Door Hardware."

D. Keying: Master key system. Permanently inscribe each key with a visual key control number and include notation "DO NOT DUPLICATE".

2.4 ACCESSORIES

A. Fasteners and Accessories: Manufacturer’s standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.
   1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
   2. Reinforce members as required to receive fastener threads.

B. Anchors: Three-way adjustable anchors with minimum adjustment of 1 inch (25.4 mm) that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.

C. Door Silencers: Manufacturer’s standard continuous mohair, wool pile, or vinyl seals.

D. Glazing Gaskets: Manufacturer’s standard extruded or molded plastic, to accommodate glazing thickness indicated.

2.5 FABRICATION

A. Provide concealed corner reinforcements and alignment clips for accurately fitted hairline joints at butted or mitered connections.

B. Factory prepare interior aluminum frames to receive templated mortised hardware; include cutouts, reinforcements, mortising, drilling, and tapping, according to the Door Hardware Schedule and templates furnished as specified in Section 087100 "Door Hardware." Fabricate frames for glazing with removable stops to allow glazing replacement without dismantling frame.
   1. Locate removable stops on the inside of spaces accessed by keyed doors.

C. Door Frames: Reinforce as required to support loads imposed by door operation and for installing entrance door hardware.

D. Door Hardware Installation: Factory install entrance door hardware to the greatest extent possible. Cut, drill, and tap for factory-installed entrance door hardware before applying finishes.

E. Fabricate components to allow secure installation without exposed fasteners.

2.6 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM’s "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.7 ALUMINUM FINISHES

A. Finish after fabrication.

B. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, floors, and ceilings, with Installer present, for conditions affecting performance of the Work.

B. Verify that wall thickness does not exceed standard tolerances allowed by throat size indicated.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install interior aluminum frames plumb, rigid, properly aligned, and securely fastened in place; comply with manufacturer's written instructions.

B. Set frames accurately in position and plumbed, aligned, and securely anchored to substrates.

C. Install frame components in the longest possible lengths; components up to 72 inches long must be one piece.

1. Fasten to suspended ceiling grid on maximum 48-inch centers, using sheet metal screws or other fasteners approved by frame manufacturer. Provide above-ceiling knee bracing to structure above at 48-inches on center staggered each direction

2. Use concealed installation clips to produce tightly fitted and aligned splices and connections.

3. Secure clips to extruded main-frame components and not to snap-in or trim members.

4. Do not leave screws or other fasteners exposed to view when installation is complete.

D. Install glazing as specified in Section 088000 "Glazing."

E. Doors: Install wood doors according to Section 081416 "Flush Wood Doors" to produce smooth operation and tight fit at contact points.

F. Field-Installed Door Hardware: Install surface-mounted entrance door hardware according to entrance door hardware manufacturers' written instructions using concealed fasteners to greatest extent possible.
3.3 ERECTION TOLERANCES

A. Erection Tolerances: Install aluminum-framed entrances and storefronts to comply with the following maximum tolerances:
   1. Plumb: 1/8 inch in 10 feet; 1/4 inch in 40 feet.
   2. Level: 1/8 inch in 20 feet; 1/4 inch in 40 feet.
   3. Alignment:
      a. Where surfaces abut in line or are separated by reveal or protruding element up to 1/2 inch wide, limit offset from true alignment to 1/16 inch.
      b. Where surfaces are separated by reveal or protruding element from 1/2 to 1 inch wide, limit offset from true alignment to 1/8 inch.
      c. Where surfaces are separated by reveal or protruding element of 1 inch wide or more, limit offset from true alignment to 1/4 inch.
   4. Location: Limit variation from plane to 1/8 inch in 12 feet; 1/2 inch over total length.

3.4 CLEANING

A. Clean exposed frame surfaces promptly after installation, using cleaning methods recommended by frame manufacturer and according to AAMA 609 & 610.

B. Touch up marred frame surfaces so touchup is not visible from a distance of 48 inches. Remove and replace frames with damaged finish that cannot be satisfactorily repaired.

END OF SECTION
SECTION 084229.23 - SLIDING AUTOMATIC ENTRANCES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes exterior, sliding, power-operated automatic entrances.

1.3 DEFINITIONS

A. AAADM: American Association of Automatic Door Manufacturers.

B. Activation Device: A control that, when actuated, sends an electrical signal to the door operator to open the door.


D. Safety Device: A control that, to avoid injury, prevents a door from opening or closing.

E. For automatic door terminology, refer to BHMA A156.10 for definitions of terms.

1.4 COORDINATION

A. Coordinate sizes and locations of recesses in concrete floors for recessed sliding tracks that control automatic entrances. Concrete, reinforcement, and formwork requirements are specified elsewhere.

B. Templates: Distribute for doors, frames, and other work specified to be factory prepared for installing automatic entrances.

C. Coordinate hardware with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish. Coordinate hardware for automatic entrances with hardware required for rest of Project.

D. Electrical System Roughing-in: Coordinate layout and installation of automatic entrances with connections to power supplies and access-control system.

1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
1.6 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal and Samples submittal. Ensure compliance with requirements included in Section 013300 "Submittal Procedures."

B. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for automatic entrances.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Shop Drawings: For automatic entrances.
   1. Include plans, elevations, sections, hardware mounting heights, and attachment details.
   2. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Indicate locations of activation and safety devices.
   5. Include hardware schedule and indicate hardware types, functions, quantities, and locations.

D. Samples for Verification: For each type of exposed finish required, in manufacturer's standard sizes.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For automatic entrances, safety devices, and control systems to include in operation and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative, with certificate issued by AAADM, who is trained for installation and maintenance of units required for this Project.
   1. Maintenance Proximity: Not more than two hours normal travel time from Installer's place of business to Project site.

B. Provide the following upon request:
   1. Qualification Data: For Installer.
   2. Product Certificates: For each type of automatic entrance. Include emergency-exit features of automatic entrances serving as a required means of egress.
   3. Product Test Reports: For each type of automatic entrance, for tests performed by a qualified testing agency.
   4. Field quality-control reports.

1.9 COORDINATION

A. Templates: Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing automatic entrances to comply with indicated requirements.
B. Electrical System Roughing-in: Coordinate layout and installation of automatic entrance door assemblies with connections to power supplies, and remote monitoring systems, and security access control system. See Division 28 Section "Electronic Safety and Security" for systems not provided under this section.

C. System Integration: Integrate sliding automatic entrances with other systems as required for a complete working installation.
   1. Provide electrical interface control capability for activation of sliding automatic entrances by exterior secure access system.
   2. Provide electrical interface to allow automatic entrance controls, mode of operation, to be changed by remote access system.
   3. Provide electrical interface to allow for remote monitoring of automatic entrance door panel status.
   4. Provide, supplemental relays, required to control mode of operation.
   5. See Division 28 Section Access Control for systems not provided under this section.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of automatic entrances that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures including, but not limited to, excessive deflection.
      b. Faulty operation of operators, controls, and hardware.
      c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
   2. Warranty Period: Two years from date of Substantial Completion.

B. Special Finish Warranty: Manufacturer agrees to repair or replace components on which finishes fail in materials or workmanship within specified warranty period.
   1. Deterioration includes, but is not limited to, the following:
      a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
      b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
      c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
   2. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 AUTOMATIC ENTRANCE ASSEMBLIES

A. Source Limitations: Obtain automatic entrance door assemblies through one source from a single manufacturer.

B. Certifications: Automatic sliding door systems shall be certified by the manufacturer to meet performance design criteria in accordance with the following standards:
   1. ANSI/BHMA A156.10.
   3. UL 325 listed.
   4. IBC 2012
   5. BOCA
6. CSFM, Listed.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Power-Operated Door Standard: BHMA A156.10.

E. Emergency-Exit Door Requirements: Comply with requirements of authorities having jurisdiction for automatic entrances serving as a required means of egress.

2.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Automatic entrances shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
   1. Wind and Seismic Loads: As indicated on Drawings.

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

C. Operating Temperature Range: Automatic entrances shall operate within minus 20 to plus 122 deg F.

D. Air Infiltration: Maximum air leakage through fixed glazing and framing areas of 1.25 cfm/sq. ft. of fixed entrance-system area when tested according to ASTM E 283 at a minimum static-air-pressure difference of 6.24 lbf/sq. ft.

E. Opening Force:
   1. Power-Operated Doors: Not more than 50 lbf required to manually set door in motion if power fails, and not more than 15 lbf required to open door to minimum required width.
   2. Breakaway Device for Power-Operated Doors: Not more than 50 lbf required for a breakaway door or panel to open.

F. Entrapment-Prevention Force:
   1. Power-Operated Sliding Doors: Not more than 30 lbf required to prevent stopped door from closing.

2.3 SLIDING AUTOMATIC ENTRANCES

A. General: Provide manufacturer’s standard automatic entrances including doors, sidelites, framing, headers, carrier assemblies, roller tracks, door operators, controls, and accessories required for a complete installation.

B. Biparting- Sliding Automatic Entrance:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Dura-Glide 2000 Series as manufactured by Stanley Access Technologies, or comparable product by one of the following:
      a. Besam Entrance Solutions; ASSA ABLOY.
      b. DORMA Automatics; Division of DORMA Group North America.
c. Tormax Technologies, Inc.

2. Configuration: Biparting-sliding doors with two sliding leaves sidelites on each side.
   a. Traffic Pattern: Two way.
   b. Emergency Breakaway Capability: Sliding leaves only.
   c. Mounting: Between jambs.

4. Features:
   a. Adjustable opening and closing speeds.
   b. Adjustable open check and close check speeds.
   c. Adjustable hold-open time between 0 and 30 seconds.
   d. Obstruction recycle.
   e. On/Off switch to control electric power to operator.
   f. Energy conservation switch that reduces door-opening width.
   g. Closed loop speed control with active braking and acceleration.
   h. Adjustable obstruction recycle time delay.
   i. Self-adjusting stop position.
   j. Self-adjusting closing compression force.
   k. Onboard sensor power supply.
   l. Onboard sensor monitoring.
   m. Optional Switch to open/Switch to close operation.
   n. Fire alarm interface, configurable to safely open or close the entrance on signal from fire alarm system.

5. Sliding-Door Carrier Assemblies and Overhead Roller Tracks: Carrier assembly that allows vertical adjustment; consisting of nylon- or delrin-covered, ball-bearing-center steel wheels operating on a continuous roller track, or ball-bearing-center steel wheels operating on a nylon- or delrin-covered, continuous roller track. Support doors from carrier assembly by cantilever and pivot assembly.
   a. Rollers: Minimum of two ball-bearing roller wheels and two antirise rollers for each active leaf.

   a. Configuration: No threshold across door opening and recessed guide-track system at sidelites.

7. Controls: Activation and safety devices according to BHMA standards.
   a. Activation Device: Motion sensor mounted on each side of door header to detect pedestrians in activating zone and to open door.
   b. Safety Device: Two photoelectric beams mounted in sidelite jambs on each side of door to detect pedestrians in presence zone and to prevent door from closing.

C. Framing Members: Extruded aluminum, minimum 0.125 inch thick and reinforced as required to support imposed loads.
   1. Nominal Size: 1-3/4 by 4-1/2 inches.
   2. Extruded Glazing Stops and Applied Trim: Minimum 0.062-inch wall thickness.

D. Stile and Rail Doors: 1-3/4-inch thick, glazed doors with minimum 0.125-inch thick, extruded-aluminum tubular stile and rail members. Mechanically fasten corners with reinforcing brackets that are welded, or incorporate concealed tie-rods that span full length of top and bottom rails.
2. Stile Design: As indicated on Drawings.
3. Rail Design: As indicated on Drawings.
4. Midrail shall have integrated flush emergency panic device.

E. Sidelite(s): 1-3/4-inch deep with minimum 0.125-inch thick, extruded-aluminum tubular stile and rail members matching door design.
   1. Glazing Stops and Gaskets: Same materials and design as for stile and rail door.

F. Headers: Fabricated from minimum 0.125-inch thick extruded aluminum and extending full width of automatic entrance units to conceal door operators and controls. Provide hinged or removable access panels for service and adjustment of door operators and controls. Secure panels to prevent unauthorized access.
   1. Mounting: Concealed, with one side of header flush with framing.
   2. Capacity: Capable of supporting doors up to 220 lb per leaf over spans up to 14 feet without intermediate supports.
      a. Provide sag rods for spans exceeding 14 feet.

G. Brackets and Reinforcements: High-strength aluminum with nonstaining, nonferrous shims for aligning system components.

H. Signage: As required by cited BHMA standard.
   2. Provide sign materials with instructions for field application after glazing is installed.

2.4 MATERIALS

A. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
   1. Extrusions: ASTM B 221.

B. Glazing: As specified in Section 088000 "Glazing."

C. Sealants and Joint Fillers: As specified in Section 079200 "Joint Sealants."

D. Nonmetallic, Shrinkage-Resistant Grout: Premixed, nonmetallic, noncorrosive, nonstaining grout; complying with ASTM C 1107/C 1107M; of consistency suitable for application.

E. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.

F. Fasteners and Accessories: Corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.

2.5 DOOR OPERATORS AND CONTROLS

A. General: Provide operators and controls, which include activation and safety devices, according to BHMA standards, for condition of exposure, and for long-term, maintenance-free operation under normal traffic load for type of occupancy indicated.

B. Door Operators: Provide door operators of size recommended by manufacturer for door size, weight, and movement.
1. Door Operator Performance: Door operators shall open and close doors and maintain them in fully closed position when subjected to Project's design wind loads.

2. Electromechanical Operators: Concealed, self-contained, overhead unit powered by fractional-horsepower, permanent-magnet dc motor; with closing speed controlled mechanically by gear train and dynamically by braking action of electric motor; with solid-state microprocessor controller; UL 325; and with manual operation with power off.

C. Motion Sensors: Self-contained, K-band-frequency, microwave-scanner units; fully enclosed by its plastic housing; adjustable to provide detection-field sizes and functions required by BHMA A156.10.
   1. Provide capability for switching between bidirectional and unidirectional detection.

D. Photoelectric Beams: Pulsed infrared, sender-receiver assembly for recessed mounting. Beams shall not be active when doors are fully closed.

E. Access Control Locking System: Provide access control locking hardware on sliding automatic entrances as follows:
   1. System shall include:
      a. A fail-secure electric solenoid locking device with a self-contained solid-state electronic control factory mounted inside the header.
      b. Vertical rod exit devices incorporated into the sliding door panels that prevent breakout until rod is released.
   2. When set for secure operation, the automatic sliding entrance(s) shall electrically latch in the closed position preventing door panels from sliding manually, returning the system to its locked status.
   3. During a power interruption:
      a. The solenoid lock shall be engaged, preventing the doors from sliding manually.
      b. Means of egress shall be accomplished by exit device. Exit device shall be concealed vertical rod tamper proof exit device with recessed flush mounted interior release hardware that shall prohibit manual breakout of door(s) from exterior. Flush mounted release hardware shall be concealed within the horizontal muntin bar.
   4. Key Switch: Provide exterior jamb-mounted key switch with momentary action switch.

F. Electrical Interlocks: Unless units are equipped with self-protecting devices or circuits, provide electrical interlocks to prevent activation of operator when door is locked, latched, or bolted.

2.6 HARDWARE

A. General: Provide units in sizes and types recommended by automatic entrance and hardware manufacturers for entrances and uses indicated. Finish exposed parts to match door finish unless otherwise indicated.

B. Breakaway Device for Power-Operated Doors: Device that allows door to swing out in direction of egress to full 90 degrees from any operating position. Maximum force to open door shall be as stipulated in "Performance Requirements" Article. Interrupt powered operation of door operator while in breakaway mode.

   1. Limit Arms: Limit arms shall be provided to control swing of sliding panels on break-out; swing shall not exceed 90 degrees. Limit arms shall be spring loaded to prevent shock, and include adjustable friction damping.

C. Deadlocks: Deadbolt operated by exterior cylinder and interior thumb turn, with minimum 1-inch-long throw bolt; BHMA A156.5, Grade 1.
1. Cylinders: As specified in Section 087100 "Door Hardware."
   a. Keying: Integrate into building master key system.

D. Control Switch: Provide manufacturer's standard keyed rotary switch mounted on the interior jamb and door position switch to allow for full control of the automatic entrance door. Controls to include, but are not limited to:
   1. One-way traffic; secure.
   2. Reduced Opening
   3. Open/Closed/Automatic

E. Power Switch: Sliding automatic entrances shall be equipped with a two position "On/Off" illuminated rocker switch to control power to the door.

F. Weather Stripping: Replaceable components.
   1. Sliding Type: AAMA 701, made of wool, polypropylene, or nylon woven pile with nylon-fabric or aluminum-strip backing; mortise into door, at perimeter of doors and breakaway sidelites.

2.7 FABRICATION

A. General: Factory fabricate automatic entrance components to designs, sizes, and thicknesses indicated and to comply with indicated standards.
   1. Form aluminum shapes before finishing.
   2. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.
   3. Use concealed fasteners to greatest extent possible. Where exposed fasteners are required, use countersunk Phillips flat-head machine screws, finished to match framing.
      a. Where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration, use self-locking devices.
      b. Reinforce members as required to receive fastener threads.
   4. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape recommended by manufacturer for this purpose.

B. Framing: Provide automatic entrances as prefabricated assemblies. Complete fabrication, assembly, finishing, hardware application, and other work before shipment to Project site.
   1. Fabricate tubular and channel frame assemblies with welded or mechanical joints. Provide subframes and reinforcement as required for a complete system to support required loads.
   2. Perform fabrication operations in manner that prevents damage to exposed finish surfaces.
   3. Form profiles that are sharp, straight, and free of defects or deformations.
   4. Provide components with concealed fasteners and anchor and connection devices.
   5. Fabricate components with accurately fitted joints with ends coped or mitered to produce hairline joints free of burrs and distortion.
   6. Fabricate exterior components to drain condensation and water passing joints within system to the exterior.
   7. Provide anchorage and alignment brackets for concealed support of assembly from building structure.
   8. Allow for thermal expansion of exterior units.
C. Doors: Factory fabricated and assembled in profiles indicated. Reinforce as required to support imposed loads and for installing hardware.

D. Door Operators: Factory fabricated and installed in headers, including adjusting and testing.

E. Glazing: Fabricate framing with minimum glazing edge clearances for thickness and type of glazing indicated, according to GANA's "Glazing Manual."

F. Hardware: Factory install hardware to greatest extent possible; remove only as required for final finishing operation and for delivery to and installation at Project site. Cut, drill, and tap for factory-installed hardware before applying finishes.

G. Controls: Factory install activation and safety devices in doors and headers as required by BHMA A156.10 for type of door and direction of travel.

2.8 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Apply organic and anodic finishes to formed metal after fabrication unless otherwise indicated.

C. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.9 ALUMINUM FINISHES

A. High-Performance Organic Finish: Three-coat fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
   1. Minimum dry film thickness of each coat shall be 1.2 mils.
   2. Colors: Allow for two custom colors.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances, header support, and other conditions affecting performance of automatic entrances.

B. Examine roughing-in for electrical systems to verify actual locations of power connections before automatic entrance installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION

A. General: Install automatic entrances according to manufacturer's written instructions and cited BHMA standard for direction of pedestrian travel, including signage, controls, wiring, and connection to the building's power supply.

1. Do not install damaged components. Fit frame joints to produce hairline joints free of burrs and distortion. Rigidly secure nonmovement joints. Seal joints watertight.
2. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape recommended by manufacturer for this purpose.
3. Where aluminum will contact concrete or masonry, protect against corrosion by painting contact surfaces with bituminous coating.

B. Entrances: Install automatic entrances plumb and true in alignment with established lines and grades without warp or rack of framing members and doors. Anchor securely in place.

1. Install surface-mounted hardware using concealed fasteners to greatest extent possible.
2. Set headers, carrier assemblies, tracks, operating brackets, and guides level and true to location with anchorage for permanent support.
3. Install components to drain water passing joints, condensation occurring within framing members, and moisture migrating within system to exterior.
4. Level recesses for recessed thresholds using nonshrink grout.

C. Door Operators: Connect door operators to electrical power distribution system.

D. Access-Control Devices: Connect access-control devices to access-control system as specified in SDivision 28 "Access Control."

E. Controls: Install and adjust activation and safety devices according to manufacturer's written instructions and cited BHMA standard for direction of pedestrian travel. Connect control wiring according to Division 26 "Low-Voltage Electrical Power Conductors and Cables."

F. Glazing: Install glazing as specified in Section 088000 "Glazing."

G. Sealants: Comply with requirements specified in Section 079200 "Joint Sealants" to provide weathertight installation.

1. Set bottom-guide-track system, framing members and flashings in full sealant bed.
2. Seal perimeter of framing members with sealant.

H. Signage: Apply signage on both sides of each door and breakaway sidelite as required by cited BHMA standard for direction of pedestrian travel.

I. Wiring within Automatic Entrance Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's written limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 FIELD QUALITY CONTROL

A. Certified Inspector: Owner will engage a Certified Inspector to test and inspect components, assemblies, and installations, including connections.

B. Automatic entrances will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.
3.4 ADJUSTING

A. Adjust hardware, moving parts, door operators, and controls to function smoothly, and lubricate as recommended by manufacturer; comply with requirements of applicable BHMA standards.
   1. Adjust exterior doors for weathertight closure.

B. Readjust door operators and controls after repeated operation of completed installation equivalent to three days’ use by normal traffic (100 to 300 cycles).

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.5 CLEANING

A. Clean glass and metal surfaces promptly after installation. Remove excess glazing and sealant compounds, dirt, and other substances. Repair damaged finish to match original finish.
   1. Comply with requirements in Section 088000 "Glazing" for cleaning and maintaining glass.

3.6 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months’ full maintenance by skilled employees of automatic entrance Installer. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper automatic entrance operation. Parts and supplies shall be manufacturer’s authorized replacement parts and supplies.
   1. Engage a Certified Inspector to perform safety inspection after each adjustment or repair and at end of maintenance period. Furnish completed inspection reports to Owner.
   2. Perform maintenance, including emergency callback service, during normal working hours.
   3. Include 24-hour-per-day, 7-day-per-week, emergency callback service.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain automatic entrances.

END OF SECTION
SECTION 084413 - GLAZED ALUMINUM CURTAIN WALLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes conventionally glazed aluminum curtain walls.

B. Related Requirements:
   1. Section 079200 "Joint Sealants" for installation of joint sealants installed with glazed aluminum curtain walls and for sealants to the extent not specified in this Section.
   2. Section 084423 "Structural-Sealant-Glazed Curtain Walls" for structural-sealant-glazed curtain walls.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Conference shall be held at least two weeks prior to fabrication and/or installation of curtain wall system. Arrange meeting at Project site with the glazier, sealant, and gasket manufacturers' technical representatives and any others necessary to review procedures, products to be used, and schedule for the Work. Give at least two weeks notice to Architect and other concerned parties.

1.4 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 080413.

B. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Shop Drawings: For glazed aluminum curtain walls. Include plans, elevations, sections, full-size details, and attachments to other work.
   1. Include details of provisions for assembly expansion and contraction and for draining moisture occurring within the assembly to the exterior.
   2. Include full-size isometric details of each vertical-to-horizontal intersection of glazed aluminum curtain walls, showing the following:
      a. Joinery, including concealed welds.
      b. Anchorage.
      c. Expansion provisions.
d. Glazing.
e. Flashing and drainage.

3. Include laboratory mockup Shop Drawings, prepared by a qualified preconstruction testing agency, showing details of laboratory mockup.
   a. Submit mockup system Shop Drawings only after approval of wall system Shop Drawings.
   b. Resubmit Shop Drawings with changes made to glazed aluminum curtain walls to successfully complete preconstruction testing.

E. Samples for Verification: For each type of exposed finish required, in manufacturer's standard sizes. Include 2 or more samples in each set, indicating limits of variation.

F. Fabrication Sample: Of each vertical-to-horizontal intersection of assemblies, made from 12-inch lengths of full-size components and showing details of the following:
   1. Joinery, including concealed welds.
   2. Expansion provisions.
   4. Flashing and drainage.
   5. Cross-sectional sample of curtain wall showing thermal break construction.

G. Delegated-Design Submittal: For glazed aluminum curtain walls indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For glazed aluminum curtain walls to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Product Options: Information on Drawings and in Specifications establishes requirements for aesthetic effects and performance characteristics of assemblies. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction.
   1. Do not revise intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If revisions are proposed, submit comprehensive explanatory data to Architect for review.

C. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
   2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

D. Energy Performance Standards: Comply with NFRC for minimum standards of energy performance, materials, components, accessories, and fabrication. Comply with more stringent requirements if indicated.
   1. Provide NFRC-certified glazed aluminum curtain walls with an attached label.
E. Provide the following upon request:

1. Qualification Data: For qualified Installer.
2. Seismic Qualification Certificates: For glazed aluminum curtain walls, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.
3. Welding certificates.
   a. Basis for Certification: NFRC-certified energy performance values for each glazed aluminum curtain wall.
5. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified preconstruction testing agency, for glazed aluminum curtain walls, indicating compliance with performance requirements.
6. Field quality-control reports.

F. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.

1. Furnish all labor and materials to completely erect mockup units of sufficient size and configuration to demonstrate the performance capabilities of the vertical wall system. Schedule mockup erection and testing sufficiently in advance of wall system fabrication to cause no delay. Do not install mockup materials as part of the wall system.
2. After completion of mockup construction and prior to start of testing sequence, two vision glass lite and one spandrel panels are to be removed and replaced to successfully demonstrate project reglazing procedures.
3. Exact configuration will be determined during wall system shop drawing review. For purposes of bidding, include costs for a vertical mockup one bay high by two bays wide with an outside corner.
4. Mockup shall have all details complete and identical to those approved on the wall system shop drawings. Mockup shall demonstrate quality of materials, finish, and workmanship, as well as compliance with performance requirements.
5. Provide schedule for mockup fabrication, erection, glazing, sealing and testing a minimum of 30 days in advance of fabrication to permit District and Architect to coordinate monitoring and observation.
6. Field testing shall be performed on mockups according to requirements in "Field Quality Control" Article.
7. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
8. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of structural supports for glazed aluminum curtain walls by field measurements before fabrication and indicate measurements on Shop Drawings.
1.8 WARRANTY

A. Special Assembly Warranty: Standard form in which manufacturer agrees to repair or replace components of glazed aluminum curtain walls that do not comply with requirements or that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures including, but not limited to, excessive deflection.
   b. Noise or vibration created by wind and thermal and structural movements.
   c. Deterioration of metals and other materials beyond normal weathering.
   d. Water penetration through fixed glazing and framing areas.

2. Warranty Period: Five years from date of Substantial Completion.

B. Special Finish Warranty: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of factory-applied finishes within specified warranty period.

1. Deterioration includes, but is not limited to, the following:
   a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
   b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
   c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Comply with performance requirements specified, as determined by testing of manufacturer’s standard glazed aluminum curtain walls representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.

1. Glazed aluminum curtain walls shall withstand movements of supporting structure indicated on Drawings including, but not limited to, story drift, twist, column shortening, long-term creep, and deflection from uniformly distributed and concentrated live loads.

2. Failure also includes the following:
   a. Thermal stresses transferring to building structure.
   b. Glass breakage.
   c. Noise or vibration created by wind and thermal and structural movements.
   d. Loosening or weakening of fasteners, attachments, and other components.
   e. Failure of operating units.

B. Delegated Design: Design glazed aluminum curtain walls, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

C. Structural Loads:

1. Wind and Seismic Loads: As indicated on Drawings.
2. Other Design Loads: As indicated on Drawings.
D. Structural-Test Performance: Test according to ASTM E 330 as follows:
   1. When tested at positive and negative wind-load design pressures, assemblies do not
evidence deflection exceeding specified limits.
   2. When tested at 150 percent of positive and negative wind-load design pressures,
assemblies, including anchorage, do not evidence material failures, structural distress,
and permanent deformation of main framing members exceeding 0.2 percent of span.
   3. Test Durations: As required by design wind velocity, but not less than 10 seconds.

E. Deflection of Framing Members: At design wind pressure, as follows:
   1. Deflection Normal to Wall Plane: Limited to 1/175 of clear span for spans up to 13 feet 6
   inches and to 1/240 of clear span for spans greater than 13 feet 6 inches or an amount
   that restricts edge deflection of individual glazing lites to 3/4 inch, whichever is less.
   2. Deflection Parallel to Glazing Plane: Limited to amount not exceeding that which
   reduces glazing bite to less than 75 percent of design dimension and that which reduces
   edge clearance between framing members and glazing or other fixed components to less
   than 1/8 inch.
   3. Cantilever Deflection: Where framing members overhang an anchor point, limit
deflection to two times the length of cantilevered member, divided by 175.

F. Seismic Performance: Glazed aluminum curtain walls shall withstand the effects of earthquake
motions determined according to SEI/ASCE 7.
   1. Component Importance Factor is 1.0.

G. Water Penetration under Static Pressure: No evidence of water penetration through fixed
      glazing and framing areas when tested according to ASTM E 331 at a minimum
      static-air-pressure differential of 20 percent of positive wind-load design pressure, but not less
      than 10 lbf/sq. ft.

H. Water Penetration under Dynamic Pressure: No evidence of water penetration through fixed
      glazing and framing areas when tested according to AAMA 501.1 at dynamic pressure equal to
      20 percent of positive wind-load design pressure, but not less than 10 lbf/sq. ft.
      1. Controlled Water Leakage: No uncontrolled water penetrating assemblies or water
         appearing on assemblies' normally exposed interior surfaces from sources other than
         condensation. Water leakage does not include water controlled by flashing and gutters
         that does not wet insulation within the wall system and that is drained to exterior.

I. Thermal Movements: Allow for thermal movements resulting from the following maximum
change (range) in ambient and surface temperatures:
   1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.
   2. Test Interior Ambient-Air Temperature: 65 deg F.
   3. Test Performance: No buckling; stress on glass; sealant failure; excess stress on
      framing, anchors, and fasteners; or reduction of performance when tested according to
      AAMA 501.5.

J. Energy Performance: Glazed aluminum curtain walls shall have certified and labeled energy
      performance ratings in accordance with NFRC.
   1. Thermal Transmittance (U-factor): Fixed glazing and framing areas shall have U-factor
      of not more than 0.45 Btu/sq. ft. x h x deg F as determined according to NFRC 100.
   2. Solar Heat Gain Coefficient: Fixed glazing and framing areas shall have a solar heat gain
      coefficient of no greater than 0.35 as determined according to NFRC 200.
3. Air Infiltration: Maximum air leakage through fixed glazing and framing areas of 0.30 cfm/sq. ft. of fixed wall area as determined according to ASTM E 283 at a minimum static-air-pressure differential of 6.24 lbf/sq. ft.

4. Condensation Resistance: Design the wall and its components to not develop any visible interior condensation on framing members or glazing when the exterior air dry bulb temperature is 35 deg F > deg C) and the interior air dry bulb temperature is 65 deg F. Insert number and with a 35 percent relative humidity.
   a. Provide independent laboratory test reports based on AAMA 1503.1, confirming wall system performance to at least the above criteria.
   b. If independent laboratory test reports are unavailable to verify thermal performance, provide computer analysis using THERM 5 and Windows 5 software as developed by Lawrence Berkeley National Laboratory. Include in the analysis at least all principle Mullions for sill, jamb, and head conditions for vision lights and spandrel areas.

2.2 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide listed products as manufactured by Kawneer North America; an Alcoa company, or comparable product by one of the following:
   1. EFCO Corporation.
   2. Vistawall Architectural Products; Oldcastle Building Envelope.

2.3 BASIS-OF-DESIGN PRODUCTS

A. Curtain Wall Type A: Refer to Section 084423 “Structurally-Sealant-Glazed Curtain Walls.”

B. Curtain Wall Type B: Refer to Section 084423 “Structurally-Sealant-Glazed Curtain Walls.”

C. Curtain Wall Type C: Kawneer 1600 UT, System1, 4-sided captured, thermally broken.
   1. Size: 2.5-inches by 7.5-inches.

D. Curtain Wall Type D: Kawneer 1600 UT, System1, 4-sided captured, thermally broken, internal steel reinforcement.
   1. Size: 2.5-inches by 7.5-inches.

E. Source Limitations: Obtain all curtain wall systems for the Project, including framing and accessories, from single manufacturer.

2.4 MATERIALS

A. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
   2. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221.
   4. Structural Profiles: ASTM B 308/B 308M.
   5. Welding Rods and Bare Electrodes: AWS A5.10/A5.10M.
B. Steel Reinforcement: Manufacturer's standard zinc-rich, corrosion-resistant primer complying with SSPC-PS Guide No. 12.00; applied immediately after surface preparation and pretreatment. Select surface preparation methods according to recommendations in SSPC-SP COM and prepare surfaces according to applicable SSPC standard.
   1. Structural Shapes, Plates, and Bars: ASTM A 36/A 36M.
   2. Cold-Rolled Sheet and Strip: ASTM A 1008/A 1008M.
   3. Hot-Rolled Sheet and Strip: ASTM A 1011/A 1011M.

C. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

D. Recycled Content of Aluminum Components: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

E. Regional Materials: Products shall be manufactured within 100 miles (160 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.

2.5 FRAMING

A. Framing Members: Manufacturer's extruded- or formed-aluminum framing members of thickness required and reinforced as required to support imposed loads.
   2. Glazing System: Retained mechanically with gaskets on four sides.

B. Thermally Broken Construction:
   1. Provide one of the following types of thermal break construction:
      b. Struct-Link or similar construction as approved: A poured and interrupted debrided polyurethane construction that periodically leaves a measured length of aluminum web to provide structural integrity, with the debrided sections continuously sealed using an elastomeric sealant.
      c. Azon or similar construction as approved: A poured and debrided polyurethane construction with mechanically abraded surfaces that lock in the polyurethane minimizing dry shrinkage and fracturing of the polyurethane.
      d. Pressure Bar: A continuous extruded aluminum member anchored to the window framing system with mechanical fasteners and separated from the framing by an insulating non-metallic spacer.

C. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

D. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.
   1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
   2. Reinforce members as required to receive fastener threads.
E. Anchors: Three-way adjustable anchors with minimum adjustment of 1 inch that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.

F. Concealed Flashing: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials or Dead-soft, 0.018-inch-thick stainless steel, ASTM A 240/A 240M of type recommended by manufacturer.

G. Framing Sealants: Manufacturer's standard sealants [with VOC content of 250g/L or less when calculated according to 40 CFR 59, Subpart D (EPA method 24)].

2.6 GLAZING

A. Glazing: Comply with Section 088000 "Glazing."

B. Glazing Gaskets: Manufacturer's standard sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers.
   1. Provide gaskets that are compatible with glazing sealants and will provide for silicone adhesion.

C. Glazing Sealants: As recommended by manufacturer.
   1. Sealants used inside the weatherproofing system shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 INSULATED METAL PANELS

A. Insulated Metal Panels: Laminated, metal-faced flat panels with no deviations in plane exceeding 0.8 percent of panel dimension in width or length.
   1. Overall Panel Thickness: Not less than 1 inch.
   2. Exterior Skin: Aluminum.
      a. Thickness: Manufacturer's standard for finish and texture indicated.
      b. Finish: Matching framing system.
      c. Texture: Smooth.
      d. Backing Sheet: 0.157-inch-thick, cement board.
   3. Interior Skin: Manufacturer's standard galvanized-steel sheet.
      a. Thickness: Manufacturer's standard for finish and texture indicated.
      b. Finish: Low-gloss, white baked enamel.
      c. Texture: Smooth.
      d. Backing Sheet: 1/2-inch-thick, gypsum board with proprietary fire-resistance-rated core.
   4. Thermal Insulation Core: Manufacturer's standard rigid, closed-cell, polyisocyanurate board.
   5. Surface-Burning Characteristics: For exposed interior surfaces of panels, when tested according to ASTM E 84 as follows:
      a. Flame-Spread Index: 25 or less.
      b. Smoke-Developed Index: 450 or less.
2.8 ACCESSORY MATERIALS

A. Bituminous Paint: Cold-applied asphalt-mastic paint complying with SSPC-Paint 12 requirements except containing no asbestos, formulated for 30-mil thickness per coat.

2.9 FABRICATION

A. Form aluminum shapes before finishing.

B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.

C. Fabricate components that, when assembled, have the following characteristics:
   1. Profiles that are sharp, straight, and free of defects or deformations.
   2. Accurately fitted joints with ends cope or mitered.
   3. Physical and thermal isolation of glazing from framing members.
   4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
   5. Provisions for field replacement of glazing from exterior.
   6. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.
   7. Components curved to indicated radii.

D. Fabricate components that, when assembled, have the following characteristics:
   1. Internal guttering system or other means to drain water passing joints, condensation occurring within framing members, and moisture migrating within glazed aluminum curtain wall to exterior.

E. Curtain-Wall Framing: Fabricate components for assembly using shear-block system.

F. Factory-Assembled Frame Units:
   1. Rigidly secure nonmovement joints.
   2. Seal joints watertight unless otherwise indicated.
   3. Install glazing to comply with requirements in Section 088000 "Glazing."

G. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.

2.10 ALUMINUM FINISHES

A. High-Performance Organic Finish: Three-coat fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
   1. Color and Gloss: As selected by Architect from manufacturer's full range.
PART 3 - EXECUTION

3.1 MOCKUP APPROVAL

A. Do not proceed with erection of curtain wall work before completion and approval of mockups.

3.2 EXAMINATION

A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. General:
   1. Comply with manufacturer's written instructions.
   2. Do not install damaged components.
   3. Fit joints to produce hairline joints free of burrs and distortion.
   4. Rigidly secure nonmovement joints.
   5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
   6. Weld components in concealed locations to minimize distortion or discoloration of finish. Protect glazing surfaces from welding.
   7. Seal joints watertight unless otherwise indicated.

B. Approved mockups establish acceptable workmanship and quality standards of the Project.

C. Metal Protection:
   1. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape or installing nonconductive spacers as recommended by manufacturer for this purpose.
   2. Where aluminum will contact concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

D. Install components to drain water passing joints, condensation occurring within framing members, and moisture migrating within glazed aluminum curtain wall to exterior.

E. Install components plumb and true in alignment with established lines and grades.

F. Install field-glazed units according to Section 088000 "Glazing."

3.4 ERECTION TOLERANCES

A. Erection Tolerances: Install glazed aluminum curtain walls to comply with the following maximum tolerances:
   1. Plumb: 1/8 inch in 10 feet; 1/4 inch in 40 feet.
   2. Level: 1/8 inch in 20 feet; 1/4 inch in 40 feet.
   3. Alignment:
a. Where surfaces abut in line or are separated by reveal or protruding element up to 1/2 inch wide, limit offset from true alignment to 1/16 inch.

b. Where surfaces are separated by reveal or protruding element from 1/2 to 1 inch wide, limit offset from true alignment to 1/8 inch.

c. Where surfaces are separated by reveal or protruding element of 1 inch wide or more, limit offset from true alignment to 1/4 inch.

4. Location: Limit variation from plane to 1/8 inch in 12 feet; 1/2 inch over total length.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing and inspecting of representative areas of glazed aluminum curtain walls shall take place as installation proceeds to determine compliance of installed assemblies with specified requirements.

1. Air Infiltration: Areas shall be tested for air leakage of 1.5 times the rate specified for laboratory testing in "Performance Requirements" Article, but not more than 0.09 cfm/sq. ft., of fixed wall area when tested according to ASTM E 783 at a minimum static-air-pressure differential of 6.24 lbf/sq. ft..

a. Test Area: Two bays wide, but not less than 12 feet, by one story high of glazed aluminum curtain wall on mockup and in three separate locations on building facade as directed by Architect.

b. Perform tests in each test area as directed by Architect. Perform at least three tests, prior to 10, 35, and 70 percent completion.

2. Water Penetration: Areas shall be tested according to ASTM E 1105 at a minimum uniform and cyclic static-air-pressure differential of 0.67 times the static-air-pressure differential specified for laboratory testing in "Performance Requirements" Article, but not less than 6.24 lbf/sq. ft., and shall not evidence water penetration.

a. Test Area: Two bays wide, but not less than 12 feet, by one story high of glazed aluminum curtain wall on mockup and in three separate locations on building facade as directed by Architect.

b. Perform tests in each test area as directed by Architect. Perform at least three tests, prior to 10, 35, and 70 percent completion.

C. Glazed aluminum curtain walls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION
SECTION 084423 - STRUCTURAL-SEALANT-GLAZED CURTAIN WALLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Factory or Field-glazed, two-sided structural-sealant-glazed curtain-wall assemblies.

B. Related Requirements:
   1. Section 079200 "Joint Sealants" for installation of joint sealants installed with glazed aluminum curtain walls and for sealants and sealant testing to the extent not specified in this Section.
   2. Section 084413 "Glazed Aluminum Curtain Walls" for conventionally glazed curtain walls.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Conference shall be held at least two weeks prior to fabrication and/or installation of curtain wall system. Arrange meeting at Project site with the glazier, sealant, and gasket manufacturers’ technical representatives and any others necessary to review procedures, products to be used, and schedule for the Work. Give at least two weeks notice to Architect and other concerned parties.

1.4 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 080413.

B. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Shop Drawings: For structural-sealant-glazed curtain walls. Include plans, elevations, sections, full-size details, and attachments to other work.
   1. Include details of provisions for assembly expansion and contraction and for draining moisture occurring within the assembly to the exterior.
   2. Include full-size isometric details of each vertical-to-horizontal intersection of structural-sealant-glazed curtain walls, showing the following:
a. Joinery, including concealed welds.
b. Anchorage.
c. Expansion provisions.
d. Glazing.
e. Flashing and drainage.

3. Show connection to and continuity with adjacent thermal, weather, air, and vapor barriers.

E. Samples for Verification: For each type of exposed finish required, in manufacturer's standard sizes.

F. Fabrication Sample: Of each vertical-to-horizontal intersection of assemblies, made from 12-inch lengths of full-size components and showing details of the following:
   1. Joinery, including concealed welds.
   2. Expansion provisions.
   4. Flashing and drainage.

G. Delegated-Design Submittal: For structural-sealant-glazed curtain walls indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For structural-sealant-glazed curtain walls to include in maintenance manuals.

B. Maintenance Data for Structural Sealant: For structural-sealant-glazed curtain walls to include in maintenance manuals. Include ASTM C 1401 recommendations for postinstallation-phase quality-control program.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Preconstruction Testing Agency Qualifications: Qualified according to ASTM E 699 for testing indicated.

C. Product Options: Information on Drawings and in Specifications establishes requirements for aesthetic effects and performance characteristics of assemblies. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction.
   1. Do not change intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If changes are proposed, submit comprehensive explanatory data to Architect for review.

D. Structural-Sealant Glazing: Comply with ASTM C 1401 for design and installation of curtain-wall assemblies.

E. Provide the following upon request:
1. Qualification Data: For Installer and preconstruction testing agency.
2. Seismic Qualification Certificates: For glazed aluminum curtain walls, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.
   a. Basis for Certification: NFRC-certified energy performance values for each structural-sealant-glazed curtain wall.
4. Product Test Reports: For structural-sealant-glazed curtain walls, for tests performed by manufacturer and witnessed by a qualified testing agency or independently by a qualified testing agency.
5. Source quality-control reports.
6. Field quality-control reports.

1.7 MOCKUPS

A. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
1. Furnish all labor and materials to completely erect mockup units of sufficient size and configuration to demonstrate the performance capabilities of the vertical wall system. Schedule mockup erection and testing sufficiently in advance of wall system fabrication to cause no delay. Do not install mockup materials as part of the wall system.
2. After completion of mockup construction and prior to start of testing sequence, two vision glass lites and one spandrel panel are to be removed and replaced to successfully demonstrate project reglazing procedures.
3. Build mockup of typical wall area as shown on Drawings.
4. Exact configuration will be determined during wall system shop drawing review. For purposes of bidding, include costs for a vertical mockup one story high by two bays wide with an outside corner.
5. Mockup shall have all details complete and identical to those approved on the wall system shop drawings. Mockup shall demonstrate quality of materials, finish, and workmanship, as well as compliance with performance requirements.
6. Provide schedule for mockup fabrication, erection, glazing, sealing and testing a minimum of 30 days in advance of fabrication to permit ownerDistrict and Architect to coordinate monitoring and observation.
7. Field testing shall be performed on mockups according to requirements in "Field Quality Control" Article.
8. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
9. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 PRECONSTRUCTION LABORATORY TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing.
B. Preconstruction Sealant Testing: Perform sealant manufacturer's standard tests for compatibility and adhesion of each material that will come in contact with sealants for each condition.

1. Test a minimum five production-run samples each of metal, glazing, and other material. Include testing of structural sealant, weatherseal sealants, and glazing sealants.
2. Prepare samples using techniques and primers required for installed assemblies.
3. Perform tests under environmental conditions that duplicate those under which assemblies will be installed.
4. For materials that fail tests, determine corrective measures necessary to prepare each material to ensure compatibility with and adhesion of sealants including, but not limited to, specially formulated primers. After performing these corrective measures on the minimum number of samples required for each material, retest materials.

1.9 FIELD CONDITIONS

A. Verify actual locations of structural supports for structural-sealant-glazed curtain walls by field measurements before fabrication and indicate measurements on Shop Drawings.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of glazed aluminum curtain wall that do not comply with requirements or that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures including, but not limited to, excessive deflection.
   b. Noise or vibration created by wind and thermal and structural movements.
   c. Deterioration of metals and other materials beyond normal weathering.
   d. Water penetration through fixed glazing and framing areas.
2. Warranty Period: 10 years from date of Substantial Completion.

B. Special Finish Warranty: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of factory-applied finishes within specified warranty period.

1. Deterioration includes, but is not limited to, the following:
   a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
   b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
   c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
2. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design structural-sealant-glazed curtain walls.
B. General Performance: Comply with performance requirements specified, as determined by testing of structural-sealant-glazed curtain walls representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.

1. Structural-sealant-glazed curtain walls shall withstand movements of supporting structure including, but not limited to, story drift, twist, column shortening, long-term creep, and deflection from uniformly distributed and concentrated live loads.
2. Failure also includes the following:
   a. Thermal stresses transferring to building structure.
   b. Glass breakage.
   c. Noise or vibration created by wind and thermal and structural movements.
   d. Loosening or weakening of fasteners, attachments, and other components.
   e. Failure of operating units.

C. Structural Loads:
1. Wind and Seismic Loads: As indicated on Drawings.
2. Other Design Loads: As indicated on Drawings.

D. Deflection of Framing Members: At design wind pressure, as follows:
1. Deflection Normal to Wall Plane: Limited to 1/175 of clear span for spans up to 13 feet 6 inches and to 1/240 of clear span plus 1/4 inch for spans greater than 13 feet 6 inches or an amount that restricts edge deflection of individual glazing lites to 3/4 inch, whichever is less.
2. Deflection Parallel to Glazing Plane: Limited to amount not exceeding that which reduces glazing bite to less than 75 percent of design dimension and that which reduces edge clearance between framing members and glazing or other fixed components to less than 1/8 inch.
   a. Operable Units: Provide a minimum 1/16-inch clearance between framing members and operable units.
3. Cantilever Deflection: Where framing members overhang an anchor point, as follows:
   a. Perpendicular to Plane of Wall: No greater than 1/240 of clear span plus 1/4-inch for spans greater than 11 feet 8-1/4 inches or 1/175 times span, for spans less than 11 feet 8-1/4 inches.

E. Structural: Test according to ASTM E 330 as follows:
1. When tested at positive and negative wind-load design pressures, assemblies do not evidence deflection exceeding specified limits.
2. When tested at 150 percent of positive and negative wind-load design pressures, assemblies, including anchorage, do not evidence material failures, structural distress, or permanent deformation of main framing members exceeding 0.2 percent of span.
3. Test Durations: As required by design wind velocity, but not less than 10 seconds.

F. Air Infiltration: Test according to ASTM E 283 for infiltration as follows:
1. Fixed Framing and Glass Area:
   a. Maximum air leakage of 0.06 cfm/sq. ft. at a static-air-pressure differential of 6.24 lbf/sq. ft..

G. Water Penetration under Static Pressure: Test according to ASTM E 331 as follows:
1. No evidence of water penetration through fixed glazing and framing areas when tested according to a minimum static-air-pressure differential of 20 percent of positive wind-load design pressure, but not less than 15 lbf/sq. ft..

H. Water Penetration under Dynamic Pressure: Test according to AAMA 501.1 as follows:
   1. No evidence of water penetration through fixed glazing and framing areas when tested at dynamic pressure equal to 20 percent of positive wind-load design pressure, but not less than 15 lbf/sq. ft.
   2. Maximum Water Leakage: No uncontrolled water penetrating assemblies or water appearing on assemblies’ normally exposed interior surfaces from sources other than condensation. Water leakage does not include water controlled by flashing and gutters, or water that is drained to exterior.

I. Seismic Performance: Structural-sealant-glazed curtain walls shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. Seismic Drift Causing Glass Fallout: Complying with criteria for passing based on building occupancy type when tested according to AAMA 501.6 at design displacement and 1.5 times the design displacement.
   2. Vertical Interstory Movement: Complying with criteria for passing based on building occupancy type when tested according to AAMA 501.7 at design displacement and 1.5 times the design displacement.

J. Energy Performance: Certify and label energy performance according to NFRC as follows:
   1. Thermal Transmittance (U-factor): Fixed glazing and framing areas shall have U-factor of not more than 0.45 Btu/sq. ft. x h x deg F (2.55 W/sq. m x K) as determined according to NFRC 100.
   2. Solar Heat Gain Coefficient: Fixed glazing and framing areas shall have a solar heat gain coefficient of no greater than 0.35 as determined according to NFRC 200.
   3. Condensation Resistance: Design the wall and its components to not develop any visible interior condensation on framing members or glazing when the exterior air dry bulb temperature is 35 deg F and the interior air dry bulb temperature is 65 deg F with a 45 percent relative humidity.

K. Thermal Movements: Allow for thermal movements resulting from ambient and surface temperature changes:
   1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.
   2. Thermal Cycling: No buckling; stress on glass; sealant failure; excess stress on framing, anchors, and fasteners; or reduction of performance when tested according to AAMA 501.5.
      a. High Exterior Ambient-Air Temperature: That which produces an exterior metal-surface temperature of 180 deg F.
      b. Low Exterior Ambient-Air Temperature: 0 deg F.

L. Structural-Sealant Joints:
   1. Designed to carry gravity loads of glazing.
   2. Designed to produce tensile or shear stress of less than 20 psi.

M. Structural Sealant: Capable of withstanding tensile and shear stresses imposed by structural-sealant-glazed curtain walls without failing adhesively or cohesively. When tested for preconstruction adhesion and compatibility, cohesive failure of sealant shall occur before adhesive failure.
1. Adhesive failure occurs when sealant pulls away from substrate cleanly, leaving no sealant material behind.
2. Cohesive failure occurs when sealant breaks or tears within itself but does not separate from each substrate because sealant-to-substrate bond strength exceeds sealant's internal strength.
3. Perform preconstruction testing on structural sealants as indicated.

2.2 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide listed products as manufactured by Kawneer North America; an Alcoa company, or comparable product by one of the following:
   1. EFCO Corporation.
   2. Vistawall Architectural Products; Oldcastle Building Envelope.

2.3 BASIS-OF-DESIGN PRODUCTS

A. Curtain Wall Type A: Kawneer 1600 UT, System2, captured vertical, SSG horizontal, internal steel reinforcement, thermally-broken, either factor- or field-fabricated.
   1. Size: 2.5-inches by 10-inches.

B. Curtain Wall Type B: Kawneer 1600 UT, System2, captured vertical with extended beauty cap (12 inches), SSG horizontal, internal steel reinforcement, thermally broken, either factor- or field-fabricated.
   1. Size: 2.5-inches by 7.5-inches.

C. Curtain Wall Type C: Refer to Section 084413 "Glazed Aluminum Curtain Walls."

D. Curtain Wall Type D: Refer to Section 084413 "Glazed Aluminum Curtain Walls."

E. Source Limitations: Obtain all curtain wall systems for the Project, including framing and accessories, from single manufacturer.

2.4 FRAMING

A. Framing Members: Manufacturer's extruded- or formed-aluminum framing members of thickness required and reinforced as required to support imposed loads.

B. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

C. Thermally Broken Construction:
   1. Provide one of the following types of thermal break construction:
b. Struct-Link or similar construction as approved: A poured and interrupted debridged polyurethane construction that periodically leaves a measured length of aluminum web to provide structural integrity, with the debridged sections continuously sealed using an elastomeric sealant.

c. Azon or similar construction as approved: A poured and debridged polyurethane construction with mechanically abraded surfaces that lock in the polyurethane minimizing dry shrinkage and fracturing of the polyurethane.

d. Pressure Bar: A continuous extruded aluminum member anchored to the window framing system with mechanical fasteners and separated from the framing by an insulating non-metallic spacer.

2.5 MATERIALS

A. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
   2. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221.
   3. Extruded Structural Pipe and Tubes: ASTM B 429/B 429M.
   4. Structural Profiles: ASTM B 308/B 308M.

B. Steel Reinforcement:
   1. Structural Shapes, Plates, and Bars: ASTM A 36/A 36M.
   2. Cold-Rolled Sheet and Strip: ASTM A 1008/A 1008M.
   3. Hot-Rolled Sheet and Strip: ASTM A 1011/A 1011M.

C. Steel Reinforcement Primer: Manufacturer's standard zinc-rich, corrosion-resistant primer complying with SSPC-PS Guide No. 12.00; applied immediately after surface preparation and pretreatment. Select surface preparation methods according to recommendations in SSPC-SP COM, and prepare surfaces according to applicable SSPC standard.

D. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

E. Recycled Content of Aluminum Components: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

F. Regional Materials: Products shall be manufactured within 100 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

2.6 INSULATED METAL PANELS

A. Insulated Metal Panels: Laminated, metal-faced flat panels with no deviations in plane exceeding 0.8 percent of panel dimension in width or length.
   1. Overall Panel Thickness: Not less than 1 inch.
   2. Exterior Skin: Aluminum.
      a. Thickness: Manufacturer's standard for finish and texture indicated.
      b. Finish: Matching framing system.
      c. Texture: Smooth.
      d. Backing Sheet: 0.157-inch- thick, cement board.
   3. Interior Skin: Manufacturer's standard galvanized-steel sheet.
2.7 GLAZING

A. Glazing: Comply with Section 088000 "Glazing."

B. Structural Glazing Sealants: ASTM C 1184, chemically curing silicone formulation that is compatible with system components with which it comes in contact, specifically formulated and tested for use as structural sealant and approved by structural-sealant manufacturer for use in curtain-wall assembly indicated.

1. Color: As selected by Architect from manufacturer's full range of colors.

C. Weatherseal Sealants: ASTM C 920 for Type S; Grade NS; Class 25 (minimum); Uses NT, G, A, and O; chemically curing silicone formulation that is compatible with structural sealant and other system components with which it comes in contact; recommended by structural-sealant, weatherseal-sealant, and structural-sealant-glazed curtain-wall manufacturers for this use.

2. Sealant shall have a VOC content of 250 g/L or less.
3. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.8 ACCESSORIES

A. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.

1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
2. Reinforce members as required to receive fastener threads.
3. No exposed fastenings will be permitted in aluminum work, unless otherwise specified or indicated.
4. In certain locations where it is impossible or highly impractical, or in locations where exposed but hidden from view, consideration will be given to exposed fastenings where such fastenings are Phillips, flat head, or countersunk machine screws, finished to match framing system, fabricated from 300 series stainless steel.

B. Anchors: Three-way adjustable anchors with minimum adjustment of [1 inch] <Insert dimension> that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.
C. Concealed Flashing: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials or Dead-soft, 0.018-inch-thick stainless steel, ASTM A 240/A 240M of type recommended by manufacturer.

D. Bituminous Paint: Cold-applied asphalt-mastic paint complying with SSPC-Paint 12 requirements except containing no asbestos, formulated for 30-mil thickness per coat.

2.9 FABRICATION

A. Form or extrude aluminum shapes before finishing.

B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.

C. Fabricate components that, when assembled, have the following characteristics:
   1. Profiles that are sharp, straight, and free of defects or deformations.
   2. Accurately fitted joints with ends coped or mitered.
   3. Physical and thermal isolation of glazing from framing members.
   4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
   5. Provisions for field replacement of glazing from exterior.
   6. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.
   7. Components curved to indicated radii.

D. Factory-Assembled Frame Units:
   1. Rigidly secure nonmovement joints.
   2. Prepare surfaces that are in contact with structural sealant according to sealant manufacturer's written instructions, to ensure compatibility and adhesion.
   3. Preparation includes, but is not limited to, cleaning and priming surfaces.
   4. Seal joints watertight unless otherwise indicated.
   5. Install glazing to comply with requirements in Section 088000 "Glazing."

E. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.

2.10 ALUMINUM FINISHES

A. High-Performance Organic Finish: Three-coat fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
   1. Color and Gloss: As selected by Architect from manufacturer's full range.

2.11 SOURCE QUALITY CONTROL

A. Structural Sealant: Perform quality-control procedures complying with ASTM C 1401 recommendations including, but not limited to, assembly material qualification procedures, sealant testing, and assembly fabrication reviews and checks.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare surfaces that are in contact with structural sealant according to sealant manufacturer's written instructions to ensure compatibility and adhesion. Preparation includes, but is not limited to, cleaning and priming surfaces.

3.3 INSTALLATION

A. General:
   1. Comply with manufacturer's written instructions.
   2. Do not install damaged components.
   3. Fit joints to produce hairline joints free of burrs and distortion.
   4. Rigidly secure nonmovement joints.
   5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
   6. Where welding is required, weld components in concealed locations to minimize distortion or discoloration of finish. Protect glazing surfaces from welding. Perform field welding under the same requirements as for shop welding.
   7. Thoroughly clean welds and adjacent burned areas on primed surfaces and paint the areas with priming paint of type used for shop coats, or zinc rich paint for galvanized steel.
   8. Seal joints watertight unless otherwise indicated.

B. Metal Protection:
   1. Where aluminum is in contact with dissimilar metals, protect against galvanic action by painting contact surfaces with primer, applying sealant or tape, or installing nonconductive spacers as recommended by manufacturer for this purpose.
   2. Where aluminum is in contact with concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

C. Install components plumb and true in alignment with established lines and grades.

D. Install field-glazed units according to Section 088000 "Glazing."

E. Install weatherseal sealant according to Section 079200 "Joint Sealants" and according to sealant manufacturer's written instructions, to produce weatherproof joints. Install joint filler behind sealant as recommended by sealant manufacturer.
3.4 ERECTION TOLERANCES

A. Erection Tolerances: Install structural-sealant-glazed curtain walls to comply with the following maximum tolerances:

1. Plumb: 1/8 inch in 10 feet; 1/4 inch in 40 feet.
2. Level: 1/8 inch in 20 feet; 1/4 inch in 40 feet.
3. Alignment:
   a. Where surfaces abut in line or are separated by reveal or protruding element up to 1/2 inch wide, limit offset from true alignment to 1/16 inch.
   b. Where surfaces are separated by reveal or protruding element from 1/2 to 1 inch wide, limit offset from true alignment to 1/8 inch.
   c. Where surfaces are separated by reveal or protruding element of 1 inch wide or more, limit offset from true alignment to 1/4 inch.
4. Location: Limit variation from plane to 1/8 inch in 12 feet; 1/2 inch over total length.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Field Quality-Control Testing: Perform the following test on mockup and representative areas of structural-sealant-glazed curtain walls during installation.

1. Air Infiltration: ASTM E 783 at 1.5 times the rate specified for laboratory testing in "Performance Requirements" Article but not more than 0.09 cfm/sq. ft..
   a. Test Area: Two bays wide, but not less than 12 feet, by one story high of glazed aluminum curtain wall on mockup and in three separate locations on building facade as directed by Architect
   b. Perform tests in each test area as directed by Architect. Perform at least three tests, prior to 10, 35, and 70 percent completion.

2. Water Penetration: ASTM E 1105 at a minimum uniform and cyclic static-air-pressure differential of 0.67 times the static-air-pressure differential specified for laboratory testing in "Performance Requirements" Article, but not less than 6.24 lbf/sq. ft., and shall not evidence water penetration.
   a. Test Area: Two bays wide, but not less than 12 feet, by one story high of glazed aluminum curtain wall on mockup and in three separate locations on building facade as directed by Architect
   b. Perform tests in each test area as directed by Architect. Perform at least three tests, prior to 10, 35, and 70 percent completion.

C. Structural-Sealant Adhesion: Test structural sealant according to recommendations in ASTM C 1401, Destructive Test Method A, "Hand Pull Tab (Destructive)," Appendix X2.
   1. Test a minimum of four areas on each building facade.
   2. Repair installation areas damaged by testing.

D. Structural-sealant-glazed curtain walls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Aluminum sliding transaction window for interior location.
   2. Aluminum u-channel framing for all-glass window walls.

1.2 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal and Samples submittal. Ensure compliance with requirements included in Section 080413.

B. Product Data: For each type of product.
   1. Include construction details, material descriptions, glazing and fabrication methods, dimensions of individual components and profiles, hardware, and finishes for aluminum windows.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Shop Drawings: For aluminum windows.
   1. Include plans, elevations, sections, hardware, accessories, insect screens, operational clearances, and details of installation, including anchor, flashing, and sealant installation.

E. Samples for Verification: For aluminum windows and components required, showing full range of color variations for finishes, and prepared on Samples of size indicated below:
   1. Exposed Finishes: 2 by 4 inches.
   2. Exposed Hardware: Full-size units.

F. Product Schedule: For aluminum windows. Use same designations indicated on Drawings.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: A manufacturer capable of fabricating aluminum windows that meet or exceed performance requirements indicated and of documenting this performance by test reports and calculations.

B. Installer Qualifications: An installer acceptable to aluminum window manufacturer for installation of units required for this Project.

C. Provide the following upon request:
   1. Qualification Data: For manufacturer and Installer.
   2. Product Test Reports: For each type of aluminum window, for tests performed by a qualified testing agency.
   3. Field quality-control reports.
1.4  COORDINATION

A. Coordinate location of u-channel framing with blockouts in concrete slab placement for flush recessed installation in floor.

1.5  WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace aluminum windows that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Failure to meet performance requirements.
   b. Faulty operation of movable sash and hardware.
   c. Deterioration of materials and finishes beyond normal weathering.

2. Warranty Period:
   a. Window: 5 years from date of Substantial Completion.
   b. Glazing Units: 5 years from date of Substantial Completion.
   c. Aluminum Finish: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1  INTERIOR SLIDING SERVICE TRANSACTION WINDOW, TYPE IWS-4

A. Basis-of-Design: Subject to compliance with requirements, provide Model DW1800A Deluxe Manual Aluminum Frame Sliding Service Windows manufactured by C.R. Laurence Co., Inc. (CRL), or comparable by Architect approved equal.

1. Frames: 6063-T5 extruded aluminum.
2. Window glides on top-hung full-length ball-bearing slides.
3. Configuration: OX
4. Size: Overall frame sizes in accordance with the Drawings.
5. Screen: Not required.
7. Glazing: Preglazed, 6.0 mm tempered.
8. Accessories:
   a. Keyed lock.
   b. Open counter area: solid surfacing countertop in accordance with Section 123661.16.

2.2  INTERIOR CHANNEL FRAMED GLAZING, TYPE IWS-2

A. Basis-of-Design: Subject to compliance with requirements, provide Wet/Dry Glaze U-Channel Framing manufactured by C.R. Laurence Co., Inc. (CRL) in model indicated, or comparable by Architect approved equal.

1. Frames: 6063-T5 extruded aluminum, minimum 0.063 inch thick.
2. Channel Size: Provide the following or Architect approved equal:
   a. Ceiling: Standard; CRL No. WU1BLSL/240; 1 inch by 1-1/2 inch high for top load roll-in glazing gasket for recessed in gypsum board above ceiling
b. Floor: Shallow; CRL No. WU3BLSL/240; 1 inch by 1 inch high for top load roll-in glazing gasket for recess in gypsum board partition for drop in glazing.

3. Gasket: Roll-in glazing gasket; CRL No. RGG12100; gray.
4. Glazing: 1/2 inch thick tempered and laminated butt glazing complying with section 088000 “Glazing.”
   a. Interlayer: Translucent
6. Accessories:
   a. Provide metal anchor plate in ceiling for attachment to structure with angle framing or hung with threaded rods.
   b. End caps.
   c. Glazing shims.

2.3 FABRICATION

A. Fabricate aluminum windows in sizes indicated. Include a complete system for assembling components and anchoring windows.

2.4 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM’s "Metal Finishes Manual" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.5 ALUMINUM FINISHES

A. Class I, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine openings, substrates, structural support, anchorage, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Verify rough opening dimensions, levelness of sill plate, and operational clearances at transaction windows.

C. Verify concrete recess for flush u-channel installation.
D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's written instructions for installing windows, hardware, accessories, and other components.

B. Install windows level, plumb, square, true to line, without distortion or impeding thermal movement, anchored securely in place to structural support.

C. Separate aluminum and other corrodirable surfaces from sources of corrosion or electrolytic action at points of contact with other materials.

3.3 ADJUSTING, CLEANING, AND PROTECTION

A. Adjust operating sashes and hardware for a tight fit at contact points and weather stripping for smooth operation and weathertight closure.

B. Clean exposed surfaces immediately after installing windows. Avoid damaging protective coatings and finishes. Remove excess sealants, glazing materials, dirt, and other substances.
   1. Keep protective films and coverings in place until final cleaning.

C. Remove and replace glass that has been broken, chipped, cracked, abraded, or damaged during construction period.

D. Protect window surfaces from contact with contaminating substances resulting from construction operations. If contaminating substances do contact window surfaces, remove contaminants immediately according to manufacturer's written instructions.

END OF SECTION
SECTION 087100 – DOOR HARDWARE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes commercial door hardware for the following:
   1. Swinging doors.
   2. Sliding doors.
   3. Other doors to the extent indicated.

B. Door hardware includes, but is not necessarily limited to, the following:
   1. Mechanical door hardware.
   2. Electromechanical door hardware.
   3. Automatic operators.
   4. Cylinders specified for doors in other sections.

C. Related Sections:
   1. Division 08 Section “Hollow Metal Doors and Frames”.
   2. Division 08 Section “Flush Wood Doors.”
   3. Division 08 “Sound-Control Doors.”
   4. Division 08 Aluminum Storefront Entrances.”
   5. Division 08 Section “Automatic Door Operators”.
   6. Division 28 Section “Access Control”.

D. Codes and References: Comply with the version year adopted by the Authority Having Jurisdiction.
   6. NFPA 105 - Installation of Smoke Door Assemblies.
   7. UL/ULC and CSA C22.2 – Standards for Automatic Door Operators Used on Fire and Smoke Barrier Doors and Systems of Doors.
   8. State Building Codes, Local Amendments.

E. Standards: All hardware specified herein shall comply with the following industry standards:
   1. ANSI/BHMA Certified Product Standards - A156 Series
   2. UL10C – Positive Pressure Fire Tests of Door Assemblies
1.3 SUBMITTALS

A. Product Data: Manufacturer's product data sheets including installation details, material descriptions, dimensions of individual components and profiles, operational descriptions and finishes.

B. Door Hardware Schedule: Prepared by or under the supervision of supplier, detailing fabrication and assembly of door hardware, as well as procedures and diagrams. Coordinate the final Door Hardware Schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.

1. Format: Comply with scheduling sequence and vertical format in DHI's "Sequence and Format for the Hardware Schedule."

2. Organization: Organize the Door Hardware Schedule into door hardware sets indicating complete designations of every item required for each door or opening. Organize door hardware sets in same order as in the Door Hardware Sets at the end of Part 3. Submittals that do not follow the same format and order as the Door Hardware Sets will be rejected and subject to resubmission.

3. Content: Include the following information:
   a. Type, style, function, size, label, hand, and finish of each door hardware item.
   b. Manufacturer of each item.
   c. Fastenings and other pertinent information.
   d. Location of door hardware set, cross-referenced to Drawings, both on floor plans and in door and frame schedule.
   e. Explanation of abbreviations, symbols, and codes contained in schedule.
   f. Mounting locations for door hardware.
   g. Door and frame sizes and materials.
   h. Warranty information for each product.

4. Submittal Sequence: Submit the final Door Hardware Schedule at earliest possible date, particularly where approval of the Door Hardware Schedule must precede fabrication of other work that is critical in the Project construction schedule. Include Product Data, Samples, Shop Drawings of other work affected by door hardware, and other information essential to the coordinated review of the Door Hardware Schedule.

C. Shop Drawings: Details of electrified access control hardware indicating the following:

1. Wiring Diagrams: Upon receipt of approved schedules, submit detailed system wiring diagrams for power, signaling, monitoring, communication, and control of the access control system electrified hardware. Differentiate between manufacturer-installed and field-installed wiring. Include the following:
   a. Elevation diagram of each unique access controlled opening showing location and interconnection of major system components with respect to their placement in the respective door openings.
   b. Complete (risers, point-to-point) access control system block wiring diagrams.
   c. Wiring instructions for each electronic component scheduled herein.
2. Electrical Coordination: Coordinate with related sections the voltages and wiring details required at electrically controlled and operated hardware openings.

D. Keying Schedule: After a keying meeting with the owner has taken place prepare a separate keying schedule detailing final instructions. Submit the keying schedule in electronic format. Include keying system explanation, door numbers, key set symbols, hardware set numbers and special instructions. Owner must approve submitted keying schedule prior to the ordering of permanent cylinders/cores.

E. Informational Submittals:
   1. Product Test Reports: Indicating compliance with cycle testing requirements, based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified independent testing agency.

F. Operating and Maintenance Manuals: Provide manufacturers operating and maintenance manuals for each item comprising the complete door hardware installation in quantity as required in Division 01, Closeout Submittals.

1.4 QUALITY ASSURANCE

A. Manufacturers Qualifications: Engage qualified manufacturers with a minimum 5 years of documented experience in producing hardware and equipment similar to that indicated for this Project and that have a proven record of successful in-service performance.

B. Installer Qualifications: A minimum 3 years documented experience installing both standard and electrified door hardware similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

C. Door Hardware Supplier Qualifications: Experienced commercial door hardware distributors with a minimum 5 years documented experience supplying both mechanical and electromechanical hardware installations comparable in material, design, and extent to that indicated for this Project. Supplier recognized as a factory direct distributor by the manufacturers of the primary materials with a warehousing facility in Project's vicinity. Supplier to have on staff a certified Architectural Hardware Consultant (AHC) available during the course of the Work to consult with Contractor, Architect, and Owner concerning both standard and electromechanical door hardware and keying.

D. Source Limitations: Obtain each type and variety of door hardware specified in this section from a single source unless otherwise indicated.
   1. Electrified modifications or enhancements made to a source manufacturer's product line by a secondary or third party source will not be accepted.
   2. Provide electromechanical door hardware from the same manufacturer as mechanical door hardware, unless otherwise indicated.

E. Each unit to bear third party permanent label demonstrating compliance with the referenced standards.

F. Keying Conference: Conduct conference to comply with requirements in Division 01 Section "Project Meetings." Keying conference to incorporate the following criteria into the final keying schedule document:
1. Function of building, purpose of each area and degree of security required.
2. Plans for existing and future key system expansion.
3. Requirements for key control storage and software.
4. Installation of permanent keys, cylinder cores and software.
5. Address and requirements for delivery of keys.

G. Pre-Submittal Conference: Conduct coordination conference in compliance with requirements in Division 01 Section "Project Meetings" with attendance by representatives of Supplier(s), Installer(s), and Contractor(s) to review proper methods and the procedures for receiving, handling, and installing door hardware.

   1. Prior to installation of door hardware, conduct a project specific training meeting to instruct the installing contractors' personnel on the proper installation and adjustment of their respective products. Product training to be attended by installers of door hardware (including electromechanical hardware) for aluminum, hollow metal and wood doors. Training will include the use of installation manuals, hardware schedules, templates and physical product samples as required.
   2. Inspect and discuss electrical roughing-in, power supply connections, and other preparatory work performed by other trades.
   3. Review sequence of operation narratives for each unique access controlled opening.
   4. Review and finalize construction schedule and verify availability of materials.
   5. Review the required inspecting, testing, commissioning, and demonstration procedures

H. At completion of installation, provide written documentation that components were applied to manufacturer's instructions and recommendations and according to approved schedule.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Inventory door hardware on receipt and provide secure lock-up and shelving for door hardware delivered to Project site. Do not store electronic access control hardware, software or accessories at Project site without prior authorization.

B. Tag each item or package separately with identification related to the final Door Hardware Schedule, and include basic installation instructions with each item or package.

C. Deliver, as applicable, permanent keys, cylinders, cores, access control credentials, software and related accessories directly to Owner via registered mail or overnight package service. Instructions for delivery to the Owner shall be established at the "Keying Conference".

1.6 COORDINATION

A. Templates: Obtain and distribute to the parties involved templates for doors, frames, and other work specified to be factory prepared for installing standard and electrified hardware. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing hardware to comply with indicated requirements.

B. Door Hardware and Electrical Connections: Coordinate the layout and installation of scheduled electrified door hardware and related access control equipment with required connections to source power junction boxes, low voltage power supplies, detection and monitoring hardware, and fire and detection alarm systems.
C. Door and Frame Preparation: Doors and corresponding frames are to be prepared, reinforced and pre-wired (if applicable) to receive the installation of the specified electrified, monitoring, signaling and access control system hardware without additional in-field modifications.

1.7 WARRANTY

A. General Warranty: Reference Division 01, General Requirements. Special warranties specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Warranty Period: Written warranty, executed by manufacturer(s), agreeing to repair or replace components of standard and electrified door hardware that fails in materials or workmanship within specified warranty period after final acceptance by the Owner. Failures include, but are not limited to, the following:

1. Structural failures including excessive deflection, cracking, or breakage.
2. Faulty operation of the hardware.
3. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
4. Electrical component defects and failures within the systems operation.

C. Standard Warranty Period: One year from date of Substantial Completion, unless otherwise indicated.

D. Special Warranty Periods:
   1. Seven years for heavy duty cylindrical (bored) locks and latches.
   2. Five years for exit hardware.
   3. Ten years for manual surface door closer bodies.
   4. Fifteen years for manual surface door closer bodies.
   5. Twenty five years for manual surface door closer bodies.
   6. Twenty five years for manual surface door closer bodies.
   7. Twenty five years for manual surface door closer bodies.
   8. Two years for electromechanical door hardware.

1.8 MAINTENANCE SERVICE

A. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for Owner's continued adjustment, maintenance, and removal and replacement of door hardware.

PART 2 - PRODUCTS

2.1 SCHEDULED DOOR HARDWARE

A. General: Provide door hardware for each door to comply with requirements in Door Hardware Sets and each referenced section that products are to be supplied under.

B. Designations: Requirements for quantity, item, size, finish or color, grade, function, and other distinctive qualities of each type of door hardware are indicated in the Door Hardware Sets at the end of Part 3. Products are identified by using door hardware designations, as follows:
1. Named Manufacturer's Products: Product designation and manufacturer are listed for each door hardware type required for the purpose of establishing requirements. Manufacturers' names are abbreviated in the Door Hardware Schedule.

C. Substitutions: Requests for substitution and product approval for inclusive mechanical and electromechanical door hardware in compliance with the specifications must be submitted in writing and in accordance with the procedures and time frames outlined in Division 01, Substitution Procedures. Approval of requests is at the discretion of the architect, owner, and their designated consultants.

2.2 HANGING DEVICES

A. Hinges: ANSI/BHMA A156.1 certified butt hinges with number of hinge knuckles and other options as specified in the Door Hardware Sets.

1. Quantity: Provide the following hinge quantity:
   a. Two Hinges: For doors with heights up to 60 inches.
   b. Three Hinges: For doors with heights 61 to 90 inches.
   c. Four Hinges: For doors with heights 91 to 120 inches.
   d. For doors with heights more than 120 inches, provide 4 hinges, plus 1 hinge for every 30 inches of door height greater than 120 inches.

2. Hinge Size: Provide the following, unless otherwise indicated, with hinge widths sized for door thickness and clearances required:
   a. Widths up to 3'0": 4-1/2" standard or heavy weight as specified.
   b. Sizes from 3'1" to 4'0": 5" standard or heavy weight as specified.

3. Hinge Weight and Base Material: Unless otherwise indicated, provide the following:
   a. Exterior Doors: Heavy weight, non-ferrous, ball bearing or oil impregnated bearing hinges unless Hardware Sets indicate standard weight.
   b. Interior Doors: Standard weight, steel, ball bearing or oil impregnated bearing hinges unless Hardware Sets indicate heavy weight.

4. Hinge Options: Comply with the following:
   a. Non-removable Pins: Provide set screw in hinge barrel that, when tightened into a groove in hinge pin, prevents removal of pin while door is closed; for the all out-swinging lockable doors.

5. Cam Lift Hinges: Where specified provide hinges that move the door up and then lower it to create a tight seal when the door is closed.

6. Manufacturers:
   a. Bommer Industries (BO).
   b. McKinney Products; ASSA ABLOY Architectural Door Accessories (MK).

B. Pivots: ANSI/BHMA A156.4, Grade 1, certified. Space intermediate pivots equally not less than 25 inches on center apart or not more than 35 inches on center for doors over 121 inches high. Pivot hinges to have oil impregnated bronze bearing in the top pivot and a radial roller and
thrust bearing in the bottom pivot with the bottom pivot designed to carry the full weight of the door. Pivots to be UL listed for windstorm where applicable.

1. Manufacturers:
   a. Architectural Builders Hardware (AH).
   b. Rixson Door Controls (RF).

2.3 POWER TRANSFER DEVICES

A. Electrified Quick Connect Data Transfer Hinges: Provide combined electrified power and Ethernet data transfer hinges with Molex™ standardized plug connectors to accommodate the electrified functions specified in the Door Hardware Sets. Connectors plug directly to through-door wiring harnesses for connection to electric locking devices and power supplies. Wire nut connections are not acceptable.

   1. Data transfer hinges feature two 6-position and two 4-position Molex connectors, 9 multi-strand wires; 2 twisted pairs (26 AWG), 4 straight conductors (28 gauge) and 1 straight conductor (22 AWG) with concealed plug connectors eliminating the need for separate or exposed wiring. Rated 350 mA continuous @ 48 volts DC nominal, the hinge is capable of two PoE wiring configurations:
      a. Power over Data (5 wire): Power and Data supplied together over the 2 twisted 26 AWG pairs. The 22 AWG conductor is used for the earth ground connection.
      b. Data with Power over Spares (9 wire): Data over 2 twisted (26 AWG) pairs with Power over spare pairs 94 straight 28 AWG conductors. The 22 Awg conductor is used for earth ground connection.

2. Manufacturers:
   b. McKinney Products; ASSA ABLOY Architectural Door Accessories (MK) – PoE Series.
   c. Pemko Products; ASSA ABLOY Architectural Door Accessories (PE) – PoE Series.

B. Electric Door Wire Harnesses: Provide electric/data transfer wiring harnesses with standardized plug connectors to accommodate up to twelve (12) wires. Connectors plug directly to through-door wiring harnesses for connection to electric locking devices and power supplies. Provide sufficient number and type of concealed wires to accommodate electric function of specified hardware. Provide a connector for through-door electronic locking devices and from hinge to junction box above the opening. Wire nut connections are not acceptable. Determine the length required for each electrified hardware component for the door type, size and construction, minimum of two per electrified opening.

   1. Provide one each of the following tools as part of the base bid contract:
2. Manufacturers:


2.4 DOOR OPERATING TRIM

A. Flush Bolts and Surface Bolts: ANSI/BHMA A156.3 and A156.16, Grade 1, certified.

1. Flush bolts to be furnished with top rod of sufficient length to allow bolt retraction device location approximately six feet from the floor.
2. Furnish dust proof strikes for bottom bolts.
3. Surface bolts to be minimum 8” in length and U.L. listed for labeled fire doors and U.L. listed for windstorm components where applicable.
4. Provide related accessories (mounting brackets, strikes, coordinators, etc.) as required for appropriate installation and operation.
5. Manufacturers:

a. Burns Manufacturing (BU).
   b. Door Controls International (DC).
   c. Rockwood Products; ASSA ABLOY Architectural Door Accessories (RO).

B. Coordinators: ANSI/BHMA A156.3 certified door coordinators consisting of active-leaf, hold-open lever and inactive-leaf release trigger. Model as indicated in hardware sets.

1. Manufacturers:

   a. Burns Manufacturing (BU).
   b. Door Controls International (DC).
   c. Rockwood Products; ASSA ABLOY Architectural Door Accessories (RO).

C. Door Push Plates and Pulls: ANSI/BHMA A156.6 certified door pushes and pulls of type and design specified in the Hardware Sets. Coordinate and provide proper width and height as required where conflicting hardware dictates.

1. Push/Pull Plates: Minimum .050 inch thick, size as indicated in hardware sets, with beveled edges, secured with exposed screws unless otherwise indicated.
2. Door Pull and Push Bar Design: Size, shape, and material as indicated in the hardware sets. Minimum clearance of 2 1/2-inches from face of door unless otherwise indicated.
3. Offset Pull Design: Size, shape, and material as indicated in the hardware sets. Minimum clearance of 2 1/2-inches from face of door and offset of 90 degrees unless otherwise indicated.
4. Fasteners: Provide manufacturer's designated fastener type as indicated in Hardware Sets.
5. Manufacturers:

   a. Burns Manufacturing (BU).
   b. Hiawatha, Inc. (HI).
c. Rockwood Products; ASSA ABLOY Architectural Door Accessories (RO).

2.5 CYLINDERS AND KEYING

A. General: Cylinder manufacturer to have minimum (10) years experience designing secured master key systems and have on record a published security keying system policy.

B. Cylinders: Original manufacturer cylinders complying with the following:
   1. Mortise Type: Threaded cylinders with rings and cam to suit hardware application.
   2. Rim Type: Cylinders with back plate, flat-type vertical or horizontal tailpiece, and raised trim ring.
   3. Bored-Lock Type: Cylinders with tailpieces to suit locks.
   4. Mortise and rim cylinder collars to be solid and recessed to allow the cylinder face to be flush and be free spinning with matching finishes.

C. Permanent Cores: Facility standard; finish face to match lockset; complying with the following:
   1. Interchangeable Cores: Core insert, removable by use of a special key; usable with other manufacturers' cylinders.

D. Permanent Cores: Match Facility standard Schlage Everest Primus.
   1. Interchangeable Cores: Core insert, removable by use of a special key; usable with other manufacturers' cylinders.
   2. Removable Cores: Core insert, removable by use of a special key, and for use with only the core manufacturer's cylinder and door hardware. Provide removable core (small or large format) as specified in Hardware Sets.

E. Keying System: Each type of lock and cylinders to be factory keyed.
   1. Conduct specified "Keying Conference" to define and document keying system instructions and requirements.
   2. Furnish factory cut, nickel-silver large bow permanently inscribed with a visual key control number as directed by Owner.
   3. Existing System: Key locks to Owner's existing Primus system.

F. Key Quantity: Provide the following minimum number of keys:
   1. Change Keys per Cylinder: Two (2)
   2. Master Keys (per Master Key Level/Group): Five (5).

G. Construction Keying: Provide temporary keyed construction cores.

H. Key Registration List (Bitting List):
   1. Provide keying transcript list to Owner's representative in the proper format for importing into key control software.
   2. Provide transcript list in writing or electronic file as directed by the Owner.
I. Key Control Cabinet: Provide a key control system including envelopes, labels, and tags with self-locking key clips, receipt forms, 3-way visible card index, temporary markers, permanent markers, and standard metal cabinet. Key control cabinet shall have expansion capacity of 150% of the number of locks required for the project.

1. Manufacturers:
   a. Lund Equipment (LU).
   b. MMF Industries (MM).
   c. Telkee (TK).

J. Key Control Software: Provide one network version of “Key Wizard” branded key management software package that includes one year of technical support and upgrades to software at no charge. Provide factory key system formatted for importing into “Key Wizard” software.

2.6 MECHANICAL LOCKS AND LATCHING DEVICES

A. Cylindrical Locksets, Grade 1 (Heavy Duty): ANSI/BHMA A156.2, Series 4000, Grade 1 certified.

1. Furnish with solid cast levers, standard 2 3/4" backset, and 1/2" (3/4" at rated paired openings) throw brass or stainless steel latchbolt.

2. Locks are to be non-handed and fully field reversible.

3. Extended cycle test: Locks to have been cycle tested in ordinance with ANSI/BHMA 156.2 requirements to 2 million cycles.

4. Manufacturers:
   a. Sargent Manufacturing (SA) – 10 Line.
   b. Schlage (SC) – ND Series.

2.7 WIRELESS ACCESS CONTROL LOCKS

A. Wireless Access Control Mortise Locks: Wireless technology ANSI/BHMA A156.13 Grade 1 mortise lockset with integrated card reader, deadbolt monitoring, and request-to-exit and door position switch signaling in one complete unit. Motor driven locking/unlocking control of the lever handle trim, 3/4" deadlocking anti-friction latch, and 1" case-hardened steel deadbolt (optional). Lock is U.L listed and labeled for use on up to 3 hour fire rated openings. Available with or without keyed high security cylinder override.

1. Wireless access control mortise locks interface using local wireless connection between the lock unit and a communication hub located directly above the door. Communication hub connected via RS-485 to a new or existing online electronic access control system platform.

2. Fully-encrypted AES 128 wireless communication between lock and communication hub (IEEE 802.15.4, 2.4 GHz) with no proprietary programming device requirements. Locks will continue functional operation independent of wireless connection slowdown or failure.

3. Integrated card reader supports 125kHz proximity credentials; 13.56 MHz contactless credentials: HID® iCLASS (full authentication, all formats), Mifare Classic (Sector and
UID), DESFire; and CSN (Card Serial Number) reads for other common 13.56 MHz cards, including ISO 14443 A/B and ISO 15693.

4. User Interfaces: Keypad/Proximity, Proximity Only, Keypad/iCLASS, and iCLASS only, locks with a minimum of 2,000 user codes and the ability to audit the last 10,000 transactions.

5. Power Source: 6 AA alkaline batteries power supply with LED indication of locked, programming mode and low capacity warning status conditions.

6. Energy Efficient Design: Provide lock bodies which have a holding current draw of 15mA maximum, and can operate on either 12 or 24 volts. Locks are to be field configurable for fail safe or fail secure operation.

7. Outside lever rigid except when in "office" mode or valid user code is entered. Emergency override access capability with optional mechanical key cylinder retraction of lock latch bolt without necessary electronic activation.

8. Complete installation to include manufacturer's Installation Tool and USB Radio Dongle for initial lock set-up and configuration. Electronic on-line access control system platform, including communication cabling and software, by others.

9. Manufacturers:

   a. Sargent Manufacturing (SA) - Profile - N2 8200 Series.

B. Wireless Access Control Mortise Locks: Wireless technology ANSI/BHMA A156.13 Grade 1 mortise lockset with integrated card reader, deadbolt monitoring, and request-to-exit and door position switch signaling in one complete unit. Motor driven locking/unlocking control of the lever handle trim, 3/4" stainless steel latch, and optional 1" deadbolt with hardened inserts. Lock is U.L listed and labeled for use on up to 3 hour fire rated openings. Available with or without keyed high security cylinder override.

   1. Wireless access control cylindrical locks interface using local wireless connection between the lock unit and a nearby communication hub. Communication hub connected via RS-485 or Wiegand to a new or existing online electronic access control system platform.

   2. Fully-encrypted AES 128 wireless communication between lock and communication hub (IEEE 802.15.4, 2.4 GHz) with no proprietary programming device requirements. Locks will continue functional operation independent of wireless connection slowdown or failure.

   3. Integrated card reader supports 125kHz proximity credentials; 13.56 MHz contactless credentials: HID® iCLASS (full authentication, all formats, including SEOS), Mifare Classic (Sector and UID), DESFire, NFC-enabled mobile phones.

   4. Lockdown capability with maximum 10 second response.

   5. Patent pending credential cache to ensure offline access.

   6. Power Source: 6 AA alkaline batteries power supply with LED indication of locked, programming mode and low capacity warning status conditions.

   7. Energy Efficient Design: Provide lock bodies which have a holding current draw of 15mA maximum, and can operate on either 12 or 24 volts. Locks are to be field configurable for fail safe or fail secure operation.

   8. Outside lever rigid except when valid user code is entered. Emergency override access capability with optional mechanical key cylinder retraction of lock latch bolt without necessary electronic activation.

   9. Communication Hub: Provide the necessary number of hubs which is connected to the access control system via RS-485 or Wiegand as required by the system. Provide hubs factory paired with the locks, but allow for field configuration as needed.

10. Complete installation to include manufacturer's Installation Tool and USB Radio Dongle for initial lock set-up and configuration. Electronic on-line access control system platform, including communication cabling and software, by others.
11. Manufacturers:
   a. Corbin Russwin Hardware (RU) – IN100 – ML2000 Series.
   b. Sargent Manufacturing (SA) – IN100 – 7900 Series.

C. Wireless Access Control Cylindrical Locks: Wireless technology ANSI/BHMA A156.2 Grade 1 cylindrical lockset with integrated card reader and request-to-exit signaling in one complete unit. Separate DPS connects directly to lock electronics for door position (open/closed status) monitoring. Motor driven locking/unlocking control of the lever handle trim with 1/2” deadlocking stainless steel latch. Lock is U.L listed and labeled for use on up to 3 hour fire rated openings.

1. Wireless access control cylindrical locks interface using local wireless connection between the lock unit and a communication hub located directly above the door. Communication hub connected via RS-485 to a new or existing online electronic access control system platform.
2. Fully-encrypted AES 128 wireless communication between lock and communication hub (IEEE 802.15.4, 2.4 GHz) with no proprietary programming device requirements. Locks will continue functional operation independent of wireless connection slowdown or failure.
3. Integrated card reader supports 125kHz proximity credentials; 13.56 MHz contactless credentials: HID® iCLASS (full authentication, all formats), Mifare Classic (Sector and UID), DESFire; and CSN (Card Serial Number) reads for other common 13.56 MHz cards, including ISO 14443 A/B and ISO 15693.
4. User Interfaces: Keypad/Proximity, Proximity Only, Keypad/iCLASS, and iCLASS only, locks with a minimum of 2,000 user codes and the ability to audit the last 10,000 transactions.
5. Power Source: 6 AA alkaline batteries power supply with LED indication of locked, programming mode and low capacity warning status conditions.
6. Outside lever rigid except when in "office" mode or valid user code is entered. Emergency override access capability with optional mechanical key cylinder retraction of lock latch bolt without necessary electronic activation.
7. Complete installation to include manufacturer's Installation Tool and USB Radio Dongle for initial lock set-up and configuration. Electronic on-line access control system platform, including communication cabling and software, by others.

8. Manufacturers:
   a. Sargent Manufacturing (SA) - Profile - N2 10-Line Series.

D. Wireless Access Control Cylindrical Locks: Wireless technology ANSI/BHMA A156.2 Series 4000 Grade 1 cylindrical lockset with integrated card reader and request-to-exit signaling in one complete unit. Separate DPS connects directly to lock electronics for door position (open/closed status) monitoring. Motor driven locking/unlocking control of the lever handle trim with 1/2” deadlocking stainless steel latch. Lock is U.L listed and labeled for use on up to 3 hour fire rated openings.

1. Wireless access control cylindrical locks interface using local wireless connection between the lock unit and a nearby communication hub. Communication hub connected via RS-485 or Wiegand to a new or existing online electronic access control system platform.
2. Fully-encrypted AES 128 wireless communication between lock and communication hub (IEEE 802.15.4, 2.4 GHz) with no proprietary programming device requirements. Locks will continue functional operation independent of wireless connection slowdown or failure.
3. Integrated reader supports HID® 125kHz proximity credentials; or ISO 14443 A/B and ISO 15693 13.56 MHz contactless credentials: HID® iCLASS/iCLASS SE (full
authentication, all formats), MIFARE Classic, DESFire EV1 (full authentication, all formats); or Near Field Communications (NFC); or HID® SIO enabled.

4. Power Source: 6 AA alkaline batteries power supply with LED indication of locked, programming mode and low capacity warning status conditions.

5. Outside lever rigid except when valid user code is entered. Emergency override access capability with optional mechanical key cylinder retraction of lock latch bolt without necessary electronic activation.

6. Communication Hub: Provide the necessary number of hubs which is connected to the access control system via RS-485 or Wiegand as required by the system. Provide hubs factory paired with the locks, but allow for field configuration as needed.

7. Complete installation to include manufacturer's Installation Tool and USB Radio Dongle for initial lock set-up and configuration. Electronic on-line access control system platform, including communication cabling and software, by others.

8. Manufacturers:
   a. Corbin Russwin Hardware (RU) – IN100 – CL33800 Series.
   b. Sargent Manufacturing (SA) – IN100 10 Line Series.


1. Wireless access control trim interfaces using local wireless connection between the lock unit and a nearby communication hub. Communication hub connected via RS-485 or Wiegand to a new or existing online electronic access control system platform.

2. Fully-encrypted AES 128 wireless communication between lock and communication hub (IEEE 802.15.4, 2.4 GHz) with no proprietary programming device requirements. Locks will continue functional operation independent of wireless connection slowdown or failure.

3. Integrated card reader supports 125kHz proximity credentials or 13.56 MHz contactless credentials (full authentication, all formats).

4. Power Source: 4 AA alkaline batteries power supply with LED indication of locked, programming mode and low capacity warning status conditions.

5. Lever is rigid except when valid user code is entered. Emergency override access capability with optional mechanical key cylinder retraction of lock latch bolt without necessary electronic activation.

6. Communication Hub: Provide the necessary number of hubs which are connected to the access control system via RS-485 or Wiegand as required by the system. Provide hubs factory paired with the locks, but allow for field configuration as needed.

7. Manufacturers:
   a. Adams Rite (AD) – A100-3090 Series.

F. Wireless Access Control Cabinet Locks: Wireless technology ANSI/BHMA A156.2 Grade 1 cabinet lock with integrated card reader.

1. Wireless access control cabinet locks interface using local wireless connection between the lock unit and a communication hub located directly above the door. Communication hub connected via RS-485 to a new or existing online electronic access control system platform.

2. Fully-encrypted AES 128 wireless communication between lock and communication hub (IEEE 802.15.4, 2.4 GHz) with no proprietary programming device requirements.

3. Integrated card reader supports 125kHz proximity credentials; 13.56 MHz contactless HID® iCLASS (full authentication, all formats) credentials.
4. User Interfaces: Proximity Only, or iCLASS only. Locks with a minimum of 2,000 user codes and the ability to audit the last 10,000 transactions.
5. Power Source: One CR123A battery.
6. Complete installation to include manufacturer's Installation Tool and USB Radio Dongle for initial lock set-up and configuration. Electronic on-line access control system platform, including communication cabling and software, by others.

7. Manufacturers:
   a. HES (HS) – K100 Series.

G. Wireless Access Control Server Cabinet Locks: Wireless technology ANSI/BHMA A156.11 High Security Grade 1 cabinet lock with integrated card reader. Provide with or without key override feature as indicated in the hardware sets.
   1. Wireless access control cabinet locks interface using local wireless connection between the lock unit and a communication hub located directly above the door. Communication hub connected via RS-485 or Wiegand to a new or existing online electronic access control system platform.
   2. Fully-encrypted AES 128 wireless communication between lock and communication hub (IEEE 802.15.4, 2.4 GHz) with no proprietary programming device requirements.
   3. Integrated card reader supports 125kHz proximity credentials; 13.56 MHz contactless HID® iCLASS (full authentication, all formats) credentials.
   4. User Interfaces: Proximity Only, or iCLASS only. Locks with a minimum of 2,000 user codes and the ability to audit the last 10,000 transactions.
   5. Power Source: One CR123A battery.
   6. Complete installation to include manufacturer's Installation Tool and USB Radio Dongle for initial lock set-up and configuration. Electronic on-line access control system platform, including communication cabling and software, by others.

7. Manufacturers:
   a. HES (HS) – KS100 Series.

2.8 LOCK AND LATCH STRIKES

A. Strikes: Provide manufacturer's standard strike with strike box for each latch or lock bolt, with curved lip extended to protect frame, finished to match door hardware set, unless otherwise indicated, and as follows:
   1. Flat-Lip Strikes: For locks with three-piece antifriction latchbolts, as recommended by manufacturer.
   2. Extra-Long-Lip Strikes: For locks used on frames with applied wood casing trim.
   3. Aluminum-Frame Strike Box: Provide manufacturer's special strike box fabricated for aluminum framing.
   4. Double-lipped strikes: For locks at double acting doors. Furnish with retractable stop for rescue hardware applications.

B. Standards: Comply with the following:
   2. Strikes for Bored Locks and Latches: BHMA A156.2.
   3. Strikes for Auxiliary Deadlocks: BHMA A156.36.
   4. Dustproof Strikes: BHMA A156.16.
2.9 CONVENTIONAL EXIT DEVICES

A. General Requirements: All exit devices specified herein shall meet or exceed the following criteria:

1. At doors not requiring a fire rating, provide devices complying with NFPA 101 and listed and labeled for "Panic Hardware" according to UL305. Provide proper fasteners as required by manufacturer including sex nuts and bolts at openings specified in the Hardware Sets.

2. Where exit devices are required on fire rated doors, provide devices complying with NFPA 80 and with UL labeling indicating "Fire Exit Hardware". Provide devices with the proper fasteners for installation as tested and listed by UL. Consult manufacturer's catalog and template book for specific requirements.

3. Except on fire rated doors, provide exit devices with hex key dogging device to hold the pushbar and latch in a retracted position. Provide optional keyed cylinder dogging on devices where specified in Hardware Sets.

4. Devices must fit flat against the door face with no gap that permits unauthorized dogging of the push bar. The addition of filler strips is required in any case where the door light extends behind the device as in a full glass configuration.

5. Lever Operating Trim: Where exit devices require lever trim, furnish manufacturer's heavy duty escutcheon trim with threaded studs for thru-bolts.

   a. Lock Trim Design: As indicated in Hardware Sets, provide finishes and designs to match that of the specified locksets.

   b. Where function of exit device requires a cylinder, provide a cylinder (Rim or Mortise) as specified in Hardware Sets.

6. Vertical Rod Exit Devices: Where surface or concealed vertical rod exit devices are used at interior openings, provide as less bottom rod (LBR) unless otherwise indicated. Provide dust proof strikes where thermal pins are required to project into the floor.

7. Rim Exit Devices: Exit device rails shall release with less than 5 pounds of pressure per the California Building Code.

8. Narrow Stile Applications: At doors constructed with narrow stiles, or as specified in Hardware Sets, provide devices designed for maximum 2" wide stiles.


10. Rail Sizing: Provide exit device rails factory sized for proper door width application.

11. Through Bolt Installation: For exit devices and trim as indicated in Door Hardware Sets.

B. Conventional Push Rail Exit Devices (Heavy Duty): ANSI/BHMA A156.3, Grade 1 certified panic and fire exit hardware devices furnished in the functions specified in the Hardware Sets. Exit device latch to be stainless steel, pullman type, with deadlock feature.

   1. Manufacturers:

      a. Sargent Manufacturing (SA) - 80 Series.

      b. Von Duprin (VD) - 35A/98 XP Series.
C. Tubular Panic Devices: Certified panic devices conforming to ANSI/BHMA A156.3, Grade 1 Certified complying with NFPA 101 and listed and labeled for "Panic Hardware" according to UL305. Device to be ADA compliant requiring less than 5 lbs. of force to activate and meet California Building Code (2013) Sec 11B.309.4. Post mounting with optional mechanical dogging. Provide proper fasteners as required by manufacturer to meet application requirements. Provide exit devices on both leaves of pairs of doors.

1. Style: Exposed vertical rod. 1-1/4" grip diameter with interior operating panic handle in combination with exterior fixed pull handle. Panic mechanism shall be concealed within brass or stainless steel tubing. Optional entrance from exterior by a keyed cylinder.

2. Configurations (provide as specified):
   a. Full Height L-Shape Pull.
   b. Half Height L-Shape Pull.
   c. Full Height Straight Pull.
   d. Half Height Straight Pull.
   e. Half Height Centered Straight Pull.
   f. Horizontal Straight Pull.
   g. Exit Only (No Exterior Pull).

3. Push/pull operation when dogged from the inside.
5. Engraved "PUSH" signage with optional paint infill and boundary grooves.

6. Manufacturers:
   a. ASSA ABLOY Glass Solutions (GS) - PDU8500 Series

D. Tube Steel Removable Mullions: ANSI/BHMA A156.3 removable steel mullions with malleable-iron top and bottom retainers and a primed paint finish.

1. Provide keyed removable feature where specified in the Hardware Sets.
2. Provide stabilizers and mounting brackets as required.
3. Provide electrical quick connection wiring options as specified in the hardware sets.

4. Manufacturers:
   a. Corbin Russwin Hardware (RU) - 700/900 Series.
   b. Sargent Manufacturing (SA) - 980S Series.
   c. Yale Locks and Hardware (YA) - M200 Series.

2.10 WIRELESS ACCESS CONTROL EXIT DEVICES

A. Wireless Access Control Exit Hardware: Wireless technology ANSI/BHMA A156.3 Grade 1 rim and mortise exit device hardware with integrated card reader. Separate DPS connects directly to exit hardware electronics for door position (open/closed status) monitoring. Motor driven locking/unlocking control of the lever handle exit trim with 3/4" throw latch bolt. U.L listed and labeled for either panic or "fire exit hardware" for use on up to 3 hour fire rated openings. Available with or without keyed high security cylinder override trim.
1. Wireless access control exit hardware interfaces using local wireless connection between the electronic exit trim and a communication hub located directly above the door. Communication hub connected via RS-485 to a new or existing online electronic access control system platform.

2. Fully-encrypted AES 128 wireless communication between lock and communication hub (IEEE 802.15.4, 2.4 GHz) with no proprietary programming device requirements. Locks will continue functional operation independent of wireless connection slowdown or failure.

3. Integrated card reader supports 125kHz proximity credentials; 13.56 MHz contactless credentials: HID® iCLASS (full authentication, all formats), Mifare Classic (Sector and UID), DESFire; and CSN (Card Serial Number) reads for other common 13.56 MHz cards, including ISO 14443 A/B and ISO 15693.

4. User Interfaces: Keypad/Proximity, Proximity Only, Keypad/iCLASS, and iCLASS only, locks with a minimum of 2,000 user codes and the ability to audit the last 10,000 transactions.

5. Power Source: 6 AA alkaline batteries power supply with LED indication of locked, programming mode and low capacity warning status conditions.

6. Outside lever rigid except when in "passage" mode or valid user code is entered. Emergency override access capability with optional mechanical key cylinder retraction of exit device latch without necessary electronic activation.

7. Complete installation to include manufacturer's Installation Tool and USB Radio Dongle for initial lock set-up and configuration. Electronic on-line access control system platform, including communication cabling and software, by others.

8. Manufacturers:

   1) Sargent Manufacturing (SA) - Profile - N2 80 Series.

B. Wireless Access Control Exit Hardware: Wireless technology ANSI/BHMA A156.3 Grade 1 rim and mortise exit device hardware with integrated card reader. Separate DPS connects directly to exit hardware electronics for door position (open/closed status) monitoring. Motor driven locking/unlocking control of the lever handle exit trim with 3/4" throw latch bolt. U.L listed and labeled for either panic or "fire exit hardware" for use on up to 3 hour fire rated openings.

   Available with or without keyed high security cylinder override trim.
2.11 DOOR CLOSERS

A. All door closers specified herein shall meet or exceed the following criteria:

1. General: Door closers to be from one manufacturer, matching in design and style, with the same type door preparations and templates regardless of application or spring size. Closers to be non-handed with full sized covers including installation and adjusting information on inside of cover.

2. Standards: Closers to comply with UL-10C for Positive Pressure Fire Test and be U.L. listed for use of fire rated doors.

3. Cycle Testing: Provide closers which have surpassed 15 million cycles in a test witnessed and verified by UL.

4. Size of Units: Comply with manufacturer's written recommendations for sizing of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Where closers are indicated for doors required to be accessible to the physically handicapped, provide units complying with ANSI ICC/A117.1.

5. Closer Arms: Provide heavy duty, forged steel closer arms unless otherwise indicated in Hardware Sets.

6. Closers shall not be installed on exterior or corridor side of doors; where possible install closers on door for optimum aesthetics.

7. Closer Accessories: Provide door closer accessories including custom templates, special mounting brackets, spacers and drop plates as required for proper installation. Provide through-bolt and security type fasteners as specified in the hardware sets.

B. Door Closers, Surface Mounted (Large Body Cast Iron): ANSI/BHMA A156.4, Grade 1 surface mounted, heavy duty door closers with complete spring power adjustment, sizes 1 thru 6; and fully operational adjustable according to door size, frequency of use, and opening force. Closers to be rack and pinion type, one piece cast iron body construction, with adjustable backcheck and separate non-critical valves for closing sweep and latch speed control.

1. Manufacturers:
   a. LCN Closers (LC) – 4040XP Series.
   b. Norton Door Controls (NO) – 9500 Series.

2.12 DOOR STOPS AND HOLDERS

A. General: Door stops and holders to be of type and design as specified below or in the Hardware Sets.

B. Door Stops and Bumpers: ANSI/BHMA A156.16, Grade 1 certified door stops and wall bumpers. Provide wall bumpers, either convex or concave types with anchorage as indicated, unless floor or other types of door stops are specified in Hardware Sets. Do not mount floor
stops where they will impede traffic. Where floor or wall bumpers are not appropriate, provide overhead type stops and holders.

1. Manufacturers:
   a. Burns Manufacturing (BU).
   b. Hiawatha, Inc. (HI).
   c. Rockwood Products; ASSA ABLOY Architectural Door Accessories (RO).

C. Overhead Door Stops and Holders: ANSI/BHMA A156.6, Grade 1 certified overhead stops and holders to be surface or concealed types as indicated in Hardware Sets. Track, slide, arm and jamb bracket to be constructed of extruded bronze and shock absorber spring of heavy tempered steel. Provide non-handed design with mounting brackets as required for proper operation and function.

   1. Manufacturers:
      a. Rixson Door Controls (RF).
      b. Rockwood Products; ASSA ABLOY Architectural Door Accessories (RO).
      c. Sargent Manufacturing (SA).

2.13 ARCHITECTURAL SEALS

A. General: Thresholds, weatherstripping, and gasket seals to be of type and design as specified below or in the Hardware Sets. Provide continuous weatherstrip gasketing on exterior doors and provide smoke, light, or sound gasketing on interior doors where indicated. At exterior applications provide non-corrosive fasteners and elsewhere where indicated.

B. Smoke Labeled Gasketing: Assemblies complying with NFPA 105 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for smoke control ratings indicated, based on testing according to UL 1784.

   1. Provide smoke labeled perimeter gasketing at all smoke labeled openings.

C. Fire Labeled Gasketing: Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to UL-10C.

   1. Provide intumescent seals as indicated to meet UL10C Standard for Positive Pressure Fire Tests of Door Assemblies, and NPFA 252, Standard Methods of Fire Tests of Door Assemblies.

D. Sound-Rated Gasketing: Assemblies that are listed and labeled by a testing and inspecting agency, for sound ratings indicated.

E. Replaceable Seal Strips: Provide only those units where resilient or flexible seal strips are easily replaceable and readily available from stocks maintained by manufacturer.

F. Manufacturers:

   1. National Guard Products (NG).
   2. Pemko Products; ASSA ABLOY Architectural Door Accessories (PE).
2.14  FABRICATION

A. Fasteners: Provide door hardware manufactured to comply with published templates generally prepared for machine, wood, and sheet metal screws. Provide screws according to manufacturers recognized installation standards for application intended.

2.15  FINISHES

A. Standard: Designations used in the Hardware Sets and elsewhere indicate hardware finishes complying with ANSI/BHMA A156.18, including coordination with traditional U.S. finishes indicated by certain manufacturers for their products.

B. Provide quality of finish, including thickness of plating or coating (if any), composition, hardness, and other qualities complying with manufacturer’s standards, but in no case less than specified by referenced standards for the applicable units of hardware.

C. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

PART 3 - EXECUTION

3.1  EXAMINATION

A. Examine scheduled openings, with Installer present, for compliance with requirements for installation tolerances, labeled fire door assembly construction, wall and floor construction, and other conditions affecting performance.

B. Notify architect of any discrepancies or conflicts between the door schedule, door types, drawings and scheduled hardware. Proceed only after such discrepancies or conflicts have been resolved in writing.

3.2  PREPARATION

A. Hollow Metal Doors and Frames: Comply with ANSI/DHI A115 series.


3.3  INSTALLATION

A. Install each item of mechanical and electromechanical hardware and access control equipment to comply with manufacturer’s written instructions and according to specifications.

   1. Installers are to be trained and certified by the manufacturer on the proper installation and adjustment of fire, life safety, and security products including: hanging devices; locking devices; closing devices; and seals.

B. Mounting Heights: Mount door hardware units at heights indicated in following applicable publications, unless specifically indicated or required to comply with governing regulations:

2. Wood Doors: DHI WDHS.3, "Recommended Locations for Architectural Hardware for Wood Flush Doors."

3. Where indicated to comply with accessibility requirements, comply with ANSI A117.1 "Accessibility Guidelines for Buildings and Facilities."

4. Provide blocking in drywall partitions where wall stops or other wall mounted hardware is located.

C. Retrofitting: Install door hardware to comply with manufacturer's published templates and written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work specified in Division 9 Sections. Do not install surface-mounted items until finishes have been completed on substrates involved.

D. Thresholds: Set thresholds for exterior and acoustical doors in full bed of sealant complying with requirements specified in Division 7 Section "Joint Sealants."

E. Storage: Provide a secure lock up for hardware delivered to the project but not yet installed. Control the handling and installation of hardware items so that the completion of the work will not be delayed by hardware losses before and after installation.

3.4 FIELD QUALITY CONTROL

A. Field Inspection: Supplier will perform a final inspection of installed door hardware and state in report whether work complies with or deviates from requirements, including whether door hardware is properly installed, operating and adjusted.

3.5 ADJUSTING

A. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements. Maximum opening force 5lb max for interior doors and 15lbs max. for fire rated and exterior doors.

3.6 CLEANING AND PROTECTION

A. Protect all hardware stored on construction site in a covered and dry place. Protect exposed hardware installed on doors during the construction phase. Install any and all hardware at the latest possible time frame.

B. Clean adjacent surfaces soiled by door hardware installation.

C. Clean operating items as necessary to restore proper finish. Provide final protection and maintain conditions that ensure door hardware is without damage or deterioration at time of owner occupancy.
### 3.7 DEMONSTRATION

A. Instruct Owner’s maintenance personnel to adjust, operate, and maintain mechanical and electromechanical door hardware.

### 3.8 DOOR HARDWARE SETS

A. The hardware sets represent the design intent and direction of the owner and architect. They are a guideline only and should not be considered a detailed hardware schedule. Discrepancies, conflicting hardware and missing items should be brought to the attention of the architect with corrections made prior to the bidding process. Omitted items not included in a hardware set should be scheduled with the appropriate additional hardware required for proper application and functionality.

B. The supplier is responsible for handing and sizing all products and providing the correct option for the appropriate door type and material where more than one is presented in the hardware sets. Quantities listed are for each pair of doors, or for each single door.

#### Hardware Sets

**Doors: 100C**

<table>
<thead>
<tr>
<th>Set: 1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Int Pivot</td>
</tr>
<tr>
<td>2 Pivot Set</td>
</tr>
<tr>
<td>1 Removable Mullion</td>
</tr>
<tr>
<td>1 Rim Exit Device</td>
</tr>
<tr>
<td>1 Rim Exit Device</td>
</tr>
<tr>
<td>2 Core</td>
</tr>
<tr>
<td>2 Cylinder</td>
</tr>
<tr>
<td>1 Electric Strike</td>
</tr>
<tr>
<td>1 ElectroLynx Adaptor</td>
</tr>
<tr>
<td>1 SMART Pac Bridge Rectifier</td>
</tr>
<tr>
<td>2 Concealed OH Stop, HD</td>
</tr>
<tr>
<td>1 Surface Closer</td>
</tr>
<tr>
<td>1 Drop Plate</td>
</tr>
<tr>
<td>1 Automatic Opener</td>
</tr>
<tr>
<td>1 Threshold</td>
</tr>
<tr>
<td>1 Gasketing</td>
</tr>
<tr>
<td>2 Sweep</td>
</tr>
<tr>
<td>1 Receiver</td>
</tr>
<tr>
<td>2 Push Plate</td>
</tr>
</tbody>
</table>
Post:

1. Post
   - 530POST (as required for push plate mounting)
   - HID card reader and power by security contractor

Note:

1. Note
   - Doors normally closed and locked, free egress at all times. During normal operation hours doors valid card read will unlatch active door. Push pad will fire actuator on active door leaf and open door.

Set: 2.0

Doors: 101A, 129B

1. Hinge (heavy weight)
   - T4A3386 NRP
   - US32D MK

1. Rim Exit Device
   - 43 8810 5CH 525
   - US32D SA

1. Concealed OH Stop, HD
   - 1-X36 (special template as required)
   - 630 RF

1. Surface Closer
   - PR9500
   - 689 NO

1. Kick Plate
   - K1050 10" x 2" LDW BEV CSK
   - US32D RO

1. Threshold
   - 271A x FHSL14 (verify details and field condition)
   - Al PE

1. Rain Guard
   - 346C x Full Frame Width
   - Al PE

1. Gasketing
   - 290AS
   - PE

1. Sweep
   - 315CN
   - PE

Set: 3.0

Doors: R01A, R02A, R06A

1. Hinge (heavy weight)
   - T4A3386
   - US32D MK

1. Hinge (heavy weight)
   - T4A3386 PoE
   - US32D MK

1. Access Control Cyl Lock
   - SF IN220-10G77 LL (furnished by Division 28) with temp core
   - US26D SA

1. Core
   - Match Facility Standard Primus system
   - SC

1. Concealed OH Stop, HD
   - 1-X36 (special template as required)
   - 630 RF

1. Surface Closer
   - 9500
   - 689 NO
### DOOR HARDWARE

Contra Costa Community College District  
Contra Costa College  
C-4016 New Science Building – DSA Increment 2

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Model/Part Number</th>
<th>Finish</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kick Plate</td>
<td>K1050 10&quot; x 2&quot; LDW BEV CSK US32D RO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threshold</td>
<td>271A x FHSL14 (verify details and field condition)</td>
<td>Al PE</td>
<td></td>
</tr>
<tr>
<td>Rain Guard</td>
<td>346C x Full Frame Width Al PE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasketing</td>
<td>290AS</td>
<td>Al PE</td>
<td></td>
</tr>
<tr>
<td>Sweep</td>
<td>315CN</td>
<td>Al PE</td>
<td></td>
</tr>
<tr>
<td>ElectroLynx Frame Harness</td>
<td>PoE-C1500P</td>
<td>MK ⚡</td>
<td></td>
</tr>
<tr>
<td>ElectroLynx Door Harness</td>
<td>PoE-C__P (as required)</td>
<td>MK ⚡</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

**Set: 5.0**

**Doors: 122AA**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Model/Part Number</th>
<th>Finish</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinge (heavy weight)</td>
<td>T4A3386 NRP</td>
<td>US32D MK</td>
<td></td>
</tr>
<tr>
<td>Storeroom Lock</td>
<td>SF 10G04 LL with temp core US26D SA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core</td>
<td>Match Facility Standard Primus system SC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concealed OH Stop, HD</td>
<td>1-X36 (special template as required)</td>
<td>630 RF</td>
<td></td>
</tr>
<tr>
<td>Surface Closer</td>
<td>9500</td>
<td>689 NO</td>
<td></td>
</tr>
<tr>
<td>Kick Plate</td>
<td>K1050 10&quot; x 2&quot; LDW BEV CSK US32D RO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threshold</td>
<td>271A x FHSL14 (verify details and field condition)</td>
<td>Al PE</td>
<td></td>
</tr>
<tr>
<td>Rain Guard</td>
<td>346C x Full Frame Width Al PE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasketing</td>
<td>290AS</td>
<td>Al PE</td>
<td></td>
</tr>
<tr>
<td>Sweep</td>
<td>315CN</td>
<td>Al PE</td>
<td></td>
</tr>
</tbody>
</table>

**Set: 6.0**

**Doors: R04A**

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Model/Part Number</th>
<th>Finish</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinge (heavy weight)</td>
<td>T4A3386</td>
<td>US32D MK</td>
<td></td>
</tr>
<tr>
<td>Flush Bolt</td>
<td>2805</td>
<td>US26D RO</td>
<td></td>
</tr>
<tr>
<td>Storeroom Lock</td>
<td>SF 10G04 LL with temp core US26D SA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core</td>
<td>Match Facility Standard Primus system SC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordinator</td>
<td>2600 x FB x Mtg Brkts US28 RO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Closer</td>
<td>9500</td>
<td>689 NO</td>
<td></td>
</tr>
<tr>
<td>Kick Plate</td>
<td>K1050 10&quot; x 1&quot; LDW BEV CSK US32D RO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall Stop</td>
<td>409</td>
<td>US32D RO</td>
<td></td>
</tr>
<tr>
<td>Threshold</td>
<td>271A x FHSL14 (verify details and field condition)</td>
<td>Al PE</td>
<td></td>
</tr>
<tr>
<td>Rain Guard</td>
<td>346C x Full Frame Width Al PE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasketing</td>
<td>290AS</td>
<td>Al PE</td>
<td></td>
</tr>
<tr>
<td>Sweep</td>
<td>315CN</td>
<td>Al PE</td>
<td></td>
</tr>
<tr>
<td>Astragal</td>
<td>357C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Set: 7.0

**Doors:** 125A

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Hinge</td>
<td>TA2714 US26D MK</td>
</tr>
<tr>
<td>1 Flush Bolt</td>
<td>2840 US32D RO</td>
</tr>
<tr>
<td>1 Storeroom Lock</td>
<td>SF 10G04 LL with temp core US26D SA</td>
</tr>
<tr>
<td>1 Core</td>
<td>Match Facility Standard Primus system SC</td>
</tr>
<tr>
<td>1 Coordinator</td>
<td>2600 x FB x Mtg Brkts US28 RO</td>
</tr>
<tr>
<td>2 Surface Closer</td>
<td>9500 689 NO</td>
</tr>
<tr>
<td>2 Kick Plate</td>
<td>K1050 10&quot; x 1&quot; LDW BEV CSK US32D RO</td>
</tr>
<tr>
<td>2 Door Stop</td>
<td>441H US26D RO</td>
</tr>
<tr>
<td>1 Astrigal</td>
<td>by sound door manufacturer OT</td>
</tr>
<tr>
<td>1 door bottom &amp; threshold</td>
<td>by sound door manufacturer OT</td>
</tr>
<tr>
<td>1 sound seals</td>
<td>by sound door manufacturer OT</td>
</tr>
<tr>
<td>1 cam lift hinges</td>
<td>by sound door manufacturer as required OT</td>
</tr>
</tbody>
</table>

**Notes:** Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

### Set: 8.0

**Doors:** 101B, 102A, 102B, 301A

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Hinge</td>
<td>TA2714 US26D MK</td>
</tr>
<tr>
<td>1 Hinge</td>
<td>TA2714 PoE US26D MK</td>
</tr>
<tr>
<td>1 Access Control Rim Exit</td>
<td>LC 43 IN220-8877 ETL 5CH 525 (furnished by Division 28) with temp core US32D SA</td>
</tr>
<tr>
<td>1 Core</td>
<td>Match Facility Standard Primus system SC</td>
</tr>
<tr>
<td>1 Cylinder</td>
<td>Schlage LFIC with temp core 626 SC</td>
</tr>
<tr>
<td>1 Surface Closer</td>
<td>PR9500 689 NO</td>
</tr>
<tr>
<td>1 Kick Plate</td>
<td>K1050 10&quot; x 2&quot; LDW BEV CSK US32D RO</td>
</tr>
<tr>
<td>1 Wall Stop</td>
<td>409 US32D RO</td>
</tr>
<tr>
<td>3 Silencer</td>
<td>608 RO</td>
</tr>
<tr>
<td>1 ElectroLynx Frame Harness</td>
<td>PoE-C1500P MK</td>
</tr>
<tr>
<td>1 ElectroLynx Door Harness</td>
<td>PoE-C__P (as required) MK</td>
</tr>
</tbody>
</table>

**Notes:** Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

### Set: 9.0

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Hinge</td>
<td>TA2714 US26D MK</td>
</tr>
<tr>
<td>1 Rim Exit Device</td>
<td>12 LC 43 8804 ETL 5CH 525 with temp core US32D SA</td>
</tr>
<tr>
<td>1 Core</td>
<td>Match Facility Standard Primus system SC</td>
</tr>
<tr>
<td>1 Cylinder</td>
<td>Schlage LFIC with temp core 626 SC</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>1 Surface Closer</td>
<td>PR9500</td>
</tr>
<tr>
<td>1 Kick Plate</td>
<td>K1050 10&quot; x 2&quot; LDW BEV CSK</td>
</tr>
<tr>
<td>1 Door Stop</td>
<td>441H</td>
</tr>
<tr>
<td>1 Threshold</td>
<td>271A x FHSL14 (verify details and field condition)</td>
</tr>
<tr>
<td>1 Gasketing</td>
<td>S88BL</td>
</tr>
<tr>
<td>1 Sweep</td>
<td>315CN</td>
</tr>
<tr>
<td>1 Cylinder</td>
<td>Per Electrical Room requirements</td>
</tr>
</tbody>
</table>

**Set: 10.0**

Doors: 301B

3 Hinge | TA2714 | US26D | MK |
1 Exit Device (nightlatch) | 43 8804 5CH 525 (no trim) | US32D | SA |
1 Core | Match Facility Standard Primus system |
1 Cylinder | Schlage LFIC with temp core | 626 | SC |
1 Surface Closer | PR9500 | 689 | NO |
1 Kick Plate | K1050 10" x 2" LDW BEV CSK | US32D | RO |
1 Wall Stop | 409 | US32D | RO |
3 Silencer | 608 |

**Set: 11.0**

Doors: 124A, 129A, 222A, 314A

6 Hinge (heavy weight) | T4A3386 | US32D | MK |
1 Concealed Vert Rod Exit | 12 NB 43 MD8610 5CH 525 | US32D | SA |
1 Concealed Vert Rod Exit | 12 NB 43 MD8615 ETL 5CH 525 | US32D | SA |
2 Surface Closer | 9500 | 689 | NO |
2 Kick Plate | K1050 10" x 1" LDW BEV CSK | US32D | RO |
2 Electromagnetic Holder | 990 Series (per details) | 689 | RF |
1 Gasketing | S88BL |
1 Astragal | 18041CNB |

**Set: 12.0**

Doors: 246A, 323A

4 Hinge | TA2714 | US26D | MK |
1 Rim Exit Device | 12 43 8815 ETL 5CH 525 | US32D | SA |
1 Surface Closer | 9500 | 689 | NO |
1 Kick Plate | K1050 10" x 2" LDW BEV CSK | US32D | RO |
1 Electromagnetic Holder | 990 Series (per details) | 689 | RF |
1 Gasketing | S88BL |

**Set: 13.0**

Contra Costa Community College District
Contra Costa College
C-4016 New Science Building – DSA Increment 2
Doors: 318A

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinge</td>
<td>5</td>
<td>TA2714 US26D MK</td>
</tr>
<tr>
<td>Hinge PoE</td>
<td>1</td>
<td>TA2714 PoE US26D MK</td>
</tr>
<tr>
<td>Self latching top bolt only</td>
<td>1</td>
<td>Wood door 2905 US32D RO</td>
</tr>
<tr>
<td>Access Control Cyl Lock</td>
<td>1</td>
<td>SF IN220-10G77 LL (furnished by Division 28) with temp core US26D SA MK</td>
</tr>
<tr>
<td>Core</td>
<td>1</td>
<td>Match Facility Standard Primus system SC</td>
</tr>
<tr>
<td>Coordinator</td>
<td>1</td>
<td>2600 x FB x Mtg Brkts US28 RO</td>
</tr>
<tr>
<td>Surface Closer</td>
<td>1</td>
<td>9500 689 NO</td>
</tr>
<tr>
<td>Kick Plate</td>
<td>2</td>
<td>K1050 10&quot; x 1&quot; LDW BEV CSK US32D RO</td>
</tr>
<tr>
<td>Door Stop</td>
<td>1</td>
<td>441H US32D RO</td>
</tr>
<tr>
<td>Astragal</td>
<td>2</td>
<td>357C PE</td>
</tr>
<tr>
<td>Silencer</td>
<td>1</td>
<td>608 RO</td>
</tr>
<tr>
<td>ElectroLynx Frame Harness</td>
<td>1</td>
<td>PoE-C1500P MK</td>
</tr>
<tr>
<td>ElectroLynx Door Harness</td>
<td>1</td>
<td>PoE-C__P (as required) MK</td>
</tr>
</tbody>
</table>

Notes: Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

**Set: 14.0**


<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinge</td>
<td>5</td>
<td>TA2714 US26D MK</td>
</tr>
<tr>
<td>Hinge PoE</td>
<td>1</td>
<td>TA2714 PoE US26D MK</td>
</tr>
<tr>
<td>Self latching top bolt only</td>
<td>1</td>
<td>Wood door 2905 US32D RO</td>
</tr>
<tr>
<td>Access Control Cyl Lock</td>
<td>1</td>
<td>SF IN220-10G77 LL (furnished by Division 28) with temp core US26D SA MK</td>
</tr>
<tr>
<td>Core</td>
<td>1</td>
<td>Match Facility Standard Primus system SC</td>
</tr>
<tr>
<td>Coordinator</td>
<td>1</td>
<td>2600 x FB x Mtg Brkts US28 RO</td>
</tr>
<tr>
<td>Surface Closer</td>
<td>1</td>
<td>PR9500 689 NO</td>
</tr>
<tr>
<td>Kick Plate</td>
<td>2</td>
<td>K1050 10&quot; x 1&quot; LDW BEV CSK US32D RO</td>
</tr>
<tr>
<td>Wall Stop</td>
<td>1</td>
<td>409 US32D RO</td>
</tr>
<tr>
<td>Astragal</td>
<td>1</td>
<td>357C PE</td>
</tr>
<tr>
<td>Silencer</td>
<td>1</td>
<td>608 RO</td>
</tr>
<tr>
<td>ElectroLynx Frame Harness</td>
<td>1</td>
<td>PoE-C1500P MK</td>
</tr>
<tr>
<td>ElectroLynx Door Harness</td>
<td>1</td>
<td>PoE-C__P (as required) MK</td>
</tr>
</tbody>
</table>

Notes: Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

**Set: 15.0**

Doors: 122A
<table>
<thead>
<tr>
<th>5 Hinge</th>
<th>TA2714</th>
<th>US26D</th>
<th>MK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hinge Auto Flush Bolt w/Fire Bolt - Metal door</td>
<td>2848</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>1 Storeroom Lock</td>
<td>SF 41 10G04 LL with temp core</td>
<td>US26D</td>
<td>SA</td>
</tr>
<tr>
<td>1 Core</td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
<td></td>
</tr>
<tr>
<td>1 Coordinator</td>
<td>2600 x FB x Mtg Brkts</td>
<td>US28</td>
<td>RO</td>
</tr>
<tr>
<td>2 Surface Closer</td>
<td>9500</td>
<td></td>
<td>NO</td>
</tr>
<tr>
<td>2 Kick Plate</td>
<td>K1050 10&quot; x 1&quot; LDW BEV CSK</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>2 Wall Stop</td>
<td>409</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>1 Threshold</td>
<td>271A x FHSL14 (verify details and field condition)</td>
<td>Al</td>
<td>PE</td>
</tr>
<tr>
<td>1 Gasketing</td>
<td>S88BL</td>
<td></td>
<td>PE</td>
</tr>
<tr>
<td>2 Door Bottom</td>
<td>411ANBL 36&quot;</td>
<td>PE</td>
<td></td>
</tr>
<tr>
<td>1 Astragal</td>
<td>357C</td>
<td></td>
<td>PE</td>
</tr>
</tbody>
</table>

**Set: 16.0**

Doors: 120A

<table>
<thead>
<tr>
<th>6 Hinge</th>
<th>TA2714</th>
<th>US26D</th>
<th>MK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hinge Auto Flush Bolt w/Fire Bolt - Metal door</td>
<td>2848</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>1 Storeroom Lock</td>
<td>SF 41 10G04 LL with temp core</td>
<td>US26D</td>
<td>SA</td>
</tr>
<tr>
<td>1 Core</td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
<td></td>
</tr>
<tr>
<td>1 Coordinator</td>
<td>2600 x FB x Mtg Brkts</td>
<td>US28</td>
<td>RO</td>
</tr>
<tr>
<td>2 Surface Closer</td>
<td>9500</td>
<td></td>
<td>NO</td>
</tr>
<tr>
<td>2 Kick Plate</td>
<td>K1050 10&quot; x 1&quot; LDW BEV CSK</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>2 Wall Stop</td>
<td>409</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>1 Astrigal</td>
<td>by sound door manufacturer</td>
<td>OT</td>
<td></td>
</tr>
<tr>
<td>1 door bottom &amp; threshold</td>
<td>by sound door manufacturer</td>
<td>OT</td>
<td></td>
</tr>
<tr>
<td>1 sound seals</td>
<td>by sound door manufacturer</td>
<td>OT</td>
<td></td>
</tr>
<tr>
<td>1 cam lift hinges</td>
<td>by sound door manufacturer as required</td>
<td>OT</td>
<td></td>
</tr>
</tbody>
</table>

**Set: 17.0**

Doors: 316B

<table>
<thead>
<tr>
<th>5 Hinge</th>
<th>TA2714</th>
<th>US26D</th>
<th>MK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hinge</td>
<td>TA2714 PoE</td>
<td>US26D</td>
<td>MK</td>
</tr>
<tr>
<td>1 Self latching top bolt only - Wood door</td>
<td>2905</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>1 Access Control Cyl Lock</td>
<td>SF IN220-10G77 LL (furnished by Division 28) with temp core</td>
<td>US26D</td>
<td>SA</td>
</tr>
<tr>
<td>1 Core</td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
<td></td>
</tr>
<tr>
<td>1 Coordinator</td>
<td>2600 x FB x Mtg Brkts</td>
<td>US28</td>
<td>RO</td>
</tr>
<tr>
<td>1 Surface Closer</td>
<td>PR9500</td>
<td>689</td>
<td>NO</td>
</tr>
<tr>
<td>2 Kick Plate</td>
<td>K1050 10&quot; x 1&quot; LDW BEV CSK</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>2 Wall Stop</td>
<td>409</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>Item Type</td>
<td>Description</td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------------------------------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Astragal</td>
<td>357C</td>
<td>PE</td>
<td></td>
</tr>
<tr>
<td>Silencer</td>
<td>608</td>
<td>RO</td>
<td></td>
</tr>
<tr>
<td>ElectroLynx Frame Harness</td>
<td>PoE-C1500P</td>
<td>MK</td>
<td></td>
</tr>
<tr>
<td>ElectroLynx Door Harness</td>
<td>PoE-C___P (as required)</td>
<td>MK</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

**Set: 18.0**


<table>
<thead>
<tr>
<th>Item Type</th>
<th>Description</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinge</td>
<td>TA2714</td>
<td>US26D</td>
<td>MK</td>
<td></td>
</tr>
<tr>
<td>Hinge</td>
<td>TA2714 PoE</td>
<td>US26D</td>
<td>MK</td>
<td></td>
</tr>
<tr>
<td>Access Control Cyl Lock</td>
<td>SF IN220-10G77 LL (furnished by Divison 28) with temp core</td>
<td>US26D</td>
<td>SA</td>
<td></td>
</tr>
<tr>
<td>Core</td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kick Plate</td>
<td>K1050 10&quot; x 2&quot; LDW BEV CSK</td>
<td>US32D</td>
<td>RO</td>
<td></td>
</tr>
<tr>
<td>Wall Stop</td>
<td>409</td>
<td>US32D</td>
<td>RO</td>
<td></td>
</tr>
<tr>
<td>Silencer</td>
<td>608</td>
<td>RO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ElectroLynx Frame Harness</td>
<td>PoE-C1500P</td>
<td>MK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ElectroLynx Door Harness</td>
<td>PoE-C___P (as required)</td>
<td>MK</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

**Set: 19.0**


<table>
<thead>
<tr>
<th>Item Type</th>
<th>Description</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinge</td>
<td>TA2714</td>
<td>US26D</td>
<td>MK</td>
<td></td>
</tr>
<tr>
<td>Hinge</td>
<td>TA2714 PoE</td>
<td>US26D</td>
<td>MK</td>
<td></td>
</tr>
<tr>
<td>Access Control Cyl Lock</td>
<td>SF IN220-10G77 LL (furnished by Divison 28) with temp core</td>
<td>US26D</td>
<td>SA</td>
<td></td>
</tr>
<tr>
<td>Core</td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Closer</td>
<td>9500</td>
<td>689</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Kick Plate</td>
<td>K1050 10&quot; x 2&quot; LDW BEV CSK</td>
<td>US32D</td>
<td>RO</td>
<td></td>
</tr>
<tr>
<td>Wall Stop</td>
<td>409</td>
<td>US32D</td>
<td>RO</td>
<td></td>
</tr>
<tr>
<td>Silencer</td>
<td>608</td>
<td>RO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ElectroLynx Frame Harness</td>
<td>PoE-C1500P</td>
<td>MK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ElectroLynx Door Harness</td>
<td>PoE-C___P (as required)</td>
<td>MK</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

**Set: 20.0**
### Set: 21.0

Doors: 203A, 324A

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Description</th>
<th>Finish</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Hinges</td>
<td></td>
<td>TA2714</td>
<td>US26D</td>
<td>MK</td>
</tr>
<tr>
<td>1 Hinge</td>
<td></td>
<td>TA2714 PoE</td>
<td>US26D</td>
<td>MK</td>
</tr>
<tr>
<td>1 Access Control Cyl Lock</td>
<td></td>
<td>SF IN220-10G77 LL (furnished by Division 28) with temp core</td>
<td>US26D</td>
<td>SA</td>
</tr>
<tr>
<td>1 Core</td>
<td></td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
<td></td>
</tr>
<tr>
<td>1 Surface Closer</td>
<td></td>
<td>9500</td>
<td>689</td>
<td></td>
</tr>
<tr>
<td>1 Kick Plate</td>
<td></td>
<td>K1050 10&quot; x 2&quot; LDW BEV CSK</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>1 Wall Stop</td>
<td></td>
<td>409</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>3 Silencers</td>
<td></td>
<td>608</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ElectroLynx Frame Harness</td>
<td></td>
<td>PoE-C1500P</td>
<td>MK</td>
<td>⚡</td>
</tr>
<tr>
<td>1 ElectroLynx Door Harness</td>
<td></td>
<td>PoE-C__P (as required)</td>
<td>MK</td>
<td>⚡</td>
</tr>
</tbody>
</table>

Notes: Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

### Set: 22.0


<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Description</th>
<th>Finish</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Hinges</td>
<td></td>
<td>TA2714</td>
<td>US26D</td>
<td>MK</td>
</tr>
<tr>
<td>1 Hinge</td>
<td></td>
<td>TA2714 PoE</td>
<td>US26D</td>
<td>MK</td>
</tr>
<tr>
<td>1 Access Control Cyl Lock</td>
<td></td>
<td>SF IN220-10G77 LL (furnished by Division 28) with temp core</td>
<td>US26D</td>
<td>SA</td>
</tr>
<tr>
<td>1 Core</td>
<td></td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
<td></td>
</tr>
<tr>
<td>1 door bottom &amp; threshold</td>
<td></td>
<td>by sound door manufacturer</td>
<td>OT</td>
<td></td>
</tr>
<tr>
<td>1 sound seals</td>
<td></td>
<td>by sound door manufacturer</td>
<td>OT</td>
<td></td>
</tr>
<tr>
<td>1 cam lift hinges</td>
<td></td>
<td>by sound door manufacturer as required</td>
<td>OT</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.
<table>
<thead>
<tr>
<th>Item Description</th>
<th>Model Number</th>
<th>Finish</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Surface Closer</td>
<td>PR9500</td>
<td>689</td>
<td>NO</td>
</tr>
<tr>
<td>1 Kick Plate</td>
<td>K1050 10&quot; x 2&quot; LDW BEV CSK</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>1 Wall Stop</td>
<td>409</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>3 Silencer</td>
<td>608</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ElectroLynx Frame Harness</td>
<td>PoE-C1500P</td>
<td>MK</td>
<td></td>
</tr>
<tr>
<td>1 ElectroLynx Door Harness</td>
<td>PoE-C__P (as required)</td>
<td>MK</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

**Set: 23.0**

Doors: 243A

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Model Number</th>
<th>Finish</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Hinge</td>
<td>TA2714</td>
<td>US26D</td>
<td>MK</td>
</tr>
<tr>
<td>1 Hinge</td>
<td>TA2714 PoE</td>
<td>US26D</td>
<td>MK</td>
</tr>
<tr>
<td>1 Access Control Cyl Lock</td>
<td>SF IN220-10G77 LL (furnished by Division 28) with temp core</td>
<td>US26D</td>
<td>SA</td>
</tr>
<tr>
<td>1 Core</td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
<td></td>
</tr>
<tr>
<td>1 Surface Closer</td>
<td>9500</td>
<td>689</td>
<td>NO</td>
</tr>
<tr>
<td>1 Kick Plate</td>
<td>K1050 10&quot; x 2&quot; LDW BEV CSK</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>1 Wall Stop</td>
<td>409</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>1 Threshold</td>
<td>271A x FHSL14 (verify details and field condition)</td>
<td>Al</td>
<td>PE</td>
</tr>
<tr>
<td>1 Gasketing</td>
<td>S88BL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Sweep</td>
<td>315CN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ElectroLynx Frame Harness</td>
<td>PoE-C1500P</td>
<td>MK</td>
<td></td>
</tr>
<tr>
<td>1 ElectroLynx Door Harness</td>
<td>PoE-C__P (as required)</td>
<td>MK</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

**Set: 24.0**

Doors: 128A

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Model Number</th>
<th>Finish</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Hinge</td>
<td>TA2714</td>
<td>US26D</td>
<td>MK</td>
</tr>
<tr>
<td>1 Hinge</td>
<td>TA2714 PoE</td>
<td>US26D</td>
<td>MK</td>
</tr>
<tr>
<td>1 Access Control Cyl Lock</td>
<td>SF IN220-10G77 LL (furnished by Division 28) with temp core</td>
<td>US26D</td>
<td>SA</td>
</tr>
<tr>
<td>1 Core</td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
<td></td>
</tr>
<tr>
<td>1 Surface Closer</td>
<td>9500</td>
<td>689</td>
<td>NO</td>
</tr>
<tr>
<td>1 Kick Plate</td>
<td>K1050 10&quot; x 2&quot; LDW BEV CSK</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>1 Wall Stop</td>
<td>409</td>
<td>US32D</td>
<td>RO</td>
</tr>
<tr>
<td>1 ElectroLynx Frame Harness</td>
<td>PoE-C1500P</td>
<td>MK</td>
<td></td>
</tr>
<tr>
<td>1 ElectroLynx Door Harness</td>
<td>PoE-C__P (as required)</td>
<td>MK</td>
<td></td>
</tr>
</tbody>
</table>
1 door bottom & threshold by sound door manufacturer OT
1 sound seals by sound door manufacturer OT
1 cam lift hinges by sound door manufacturer as required OT

Notes: Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

Set: 25.0

Doors: 316A

<table>
<thead>
<tr>
<th>Item</th>
<th>Model</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Hinge</td>
<td>TA2714</td>
<td></td>
</tr>
<tr>
<td>1 Hinge</td>
<td>TA2714 PoE</td>
<td></td>
</tr>
</tbody>
</table>
| 1 Access Control Cyl Lock                      | SF IN220-10G77 LL (furnished by Divison 28) with temp core | US26D MK
| 1 Core                                         | Match Facility Standard Primus system | SC
| 1 Surface Closer                               | PR9500     | 689 NO    |
| 1 Kick Plate                                   | K1050 10" x 2" LDW BEV CSK | US32D RO
| 1 Wall Stop                                    | 409        | US32D RO  |
| 3 Silencer                                     | 608        | RO        |
| 1 ElectroLynx Frame Harness                    | PoE-C1500P | MK ⚡      |
| 1 ElectroLynx Door Harness                     | PoE-C__P (as required) | MK ⚡    |

Notes: Door normally closed and locked with free egress at all times. Valid credential will momentarily unlock door.

Set: 26.0

Doors: R05A

<table>
<thead>
<tr>
<th>Item</th>
<th>Model</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Hinge</td>
<td>TA2714</td>
<td>US26D MK</td>
</tr>
<tr>
<td>1 Self Latching Bolt w/Fire Bolt - Metal door</td>
<td>2949</td>
<td>US32D RO</td>
</tr>
</tbody>
</table>
| 1 Storeroom Lock                               | SF 41 10G04 LL with temp core | US26D SA
| 1 Core                                         | Match Facility Standard Primus system | SC
| 1 Coordinator                                  | 2600 x FB x Mtg Brkts | US28 RO
| 2 Surface Closer                               | 9500       | 689 NO    |
| 2 Kick Plate                                   | K1050 10" x 1" LDW BEV CSK | US32D RO
| 2 Wall Stop                                    | 409        | US32D RO  |
| 1 Gasketing                                    | S88BL      | PE        |
| 1 Astragal                                     | 357C       | PE        |

Set: 27.0

Doors: 108B, 210C

<table>
<thead>
<tr>
<th>Item</th>
<th>Model</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Hinge</td>
<td>TA2714</td>
<td>US26D MK</td>
</tr>
<tr>
<td>1 Flush Bolt</td>
<td>2840</td>
<td>US32D RO</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td>Notes</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>1 Storeroom Lock</td>
<td>SF 41 10G04 LL with temp core</td>
<td>US26D</td>
</tr>
<tr>
<td>1 Core</td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
</tr>
<tr>
<td>1 Coordinator</td>
<td>2600 x FB x Mtg Brkts</td>
<td>US28</td>
</tr>
<tr>
<td>2 Surface Closer</td>
<td>PR9500</td>
<td>689</td>
</tr>
<tr>
<td>2 Kick Plate</td>
<td>K1050 10&quot; x 1&quot; LDW BEV CSK</td>
<td>US32D</td>
</tr>
<tr>
<td>2 Wall Stop</td>
<td>409</td>
<td>RO</td>
</tr>
<tr>
<td>1 Astragal</td>
<td>357C</td>
<td>PE</td>
</tr>
<tr>
<td>2 Silencer</td>
<td>608</td>
<td>RO</td>
</tr>
</tbody>
</table>

**Set: 27.1**

Doors: 121A

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Hinge</td>
<td>TA2714</td>
<td>US26D</td>
</tr>
<tr>
<td>1 Flush Bolt</td>
<td>2840</td>
<td>US32D</td>
</tr>
<tr>
<td>1 Storeroom Lock</td>
<td>SF 41 10G04 LL with temp core</td>
<td>US26D</td>
</tr>
<tr>
<td>1 Core</td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
</tr>
<tr>
<td>1 Coordinator</td>
<td>2600 x FB x Mtg Brkts</td>
<td>US28</td>
</tr>
<tr>
<td>2 Surface Closer</td>
<td>9500</td>
<td>689</td>
</tr>
<tr>
<td>2 Kick Plate</td>
<td>K1050 10&quot; x 1&quot; LDW BEV CSK</td>
<td>US32D</td>
</tr>
<tr>
<td>2 Wall Stop</td>
<td>409</td>
<td>RO</td>
</tr>
<tr>
<td>1 Astragal</td>
<td>357C</td>
<td>PE</td>
</tr>
<tr>
<td>2 Silencer</td>
<td>608</td>
<td>RO</td>
</tr>
</tbody>
</table>

**Set: 28.0**

Doors: 103A, 122BA, 237A, 311A

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Hinge</td>
<td>TA2714</td>
<td>US26D</td>
</tr>
<tr>
<td>1 Storeroom Lock</td>
<td>SF 10G04 LL with temp core</td>
<td>US26D</td>
</tr>
<tr>
<td>1 Core</td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
</tr>
<tr>
<td>1 Surface Closer</td>
<td>9500 (PR as required)</td>
<td>689</td>
</tr>
<tr>
<td>1 Kick Plate</td>
<td>K1050 10&quot; x 2&quot; LDW BEV CSK</td>
<td>US32D</td>
</tr>
<tr>
<td>1 Wall Stop</td>
<td>409</td>
<td>US32D</td>
</tr>
<tr>
<td>3 Silencer</td>
<td>608</td>
<td>RO</td>
</tr>
</tbody>
</table>

**Set: 29.0**

Doors: 301AA

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Hinge</td>
<td>TA2714</td>
<td>US26D</td>
</tr>
<tr>
<td>1 Storeroom Lock</td>
<td>SF 10G04 LL with temp core</td>
<td>US26D</td>
</tr>
<tr>
<td>1 Core</td>
<td>Match Facility Standard Primus system</td>
<td>SC</td>
</tr>
<tr>
<td>1 Surface Closer</td>
<td>9500 (PR as required)</td>
<td>689</td>
</tr>
<tr>
<td>1 Kick Plate</td>
<td>K1050 10&quot; x 2&quot; LDW BEV CSK</td>
<td>US32D</td>
</tr>
<tr>
<td>1 Wall Stop</td>
<td>409</td>
<td>US32D</td>
</tr>
<tr>
<td>3 Silencer</td>
<td>608</td>
<td>RO</td>
</tr>
</tbody>
</table>
Set: 30.0
Doors: 223A, 315A

3 Hinge: TA2714, US26D, MK
1 Storeroom Lock: SF 10G04 LL with temp core, US26D, SA
1 Core: Match Facility Standard Primus system, SC
1 Surface Closer: 9500, 689, NO
1 Kick Plate: K1050 10" x 2" LDW BEV CSK, US32D, RO
1 Wall Stop: 409, US32D, RO
1 Threshold: 271A x FHSL14 (verify details and field condition), AI, PE
1 Gasketing: S88BL, PE
1 Sweep: 315CN, PE

Set: 31.0
Doors: 317A

8 Hinge: TA2714, US26D, MK
1 Self latching top bolt only - Wood door: 2905, US32D, RO
1 Office Lock: SF 10G05 LL with temp core, US26D, SA
1 Core: Match Facility Standard Primus system, SC
2 Kick Plate: K1050 10" x 1" LDW BEV CSK, US32D, RO
2 Wall Stop: 409, US32D, RO
1 Astragal: 357C, PE
2 Silencer: 608, RO

Set: 32.0

3 Hinge: TA2714, US26D, MK
1 Office Lock: SF 10G05 LL with temp core, US26D, SA
1 Core: Match Facility Standard Primus system, SC
1 Kick Plate: K1050 10" x 2" LDW BEV CSK, US32D, RO
1 Wall Stop: 409, US32D, RO
3 Silencer: 608, RO

Set: 33.0
Doors: 123A

3 Hinge: TA2714, US26D, MK
1 Privacy Lock: 10U65 LL with temp core, US26D, SA
1 Kick Plate: K1050 10" x 2" LDW BEV CSK, US32D, RO
1 Mop Plate: K1050 6" x 1" LDW BEV CSK, US32D, RO
<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Code</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Stop</td>
<td>1</td>
<td>409 US32D RO</td>
<td>US32D RO</td>
<td></td>
</tr>
<tr>
<td>Silencer</td>
<td>3</td>
<td>608 US32D RO</td>
<td>US32D RO</td>
<td></td>
</tr>
</tbody>
</table>

**Set: 34.0**

Doors: 126A, 127A, 244A, 244B, 321A, 322A

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Code</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinge TA2714</td>
<td>3</td>
<td>US26D MK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Push Pull Set 110x73C/73CL</td>
<td>1</td>
<td>US32D RO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Closer 9500</td>
<td>1</td>
<td>689 NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kick Plate K1050 10&quot; x 2&quot; LDW BEV CSK</td>
<td>1</td>
<td>US32D RO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mop Plate K1050 6&quot; x 1&quot; LDW BEV CSK</td>
<td>1</td>
<td>US32D RO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall Stop 409</td>
<td>1</td>
<td>US32D RO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silencer 608</td>
<td>3</td>
<td>RO US32D</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Set: 35.0**

Doors: 100A, 200A

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Code</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note</td>
<td>1</td>
<td>OT</td>
<td>All hardware by door manufacturer</td>
<td></td>
</tr>
</tbody>
</table>

**Set: 36.0**

Doors: R03A

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Code</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exit Device (passage)</td>
<td>1</td>
<td>43 8815 ETL 5CH 525 US32D SA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note</td>
<td>1</td>
<td>OT</td>
<td>balance of hardware by gate manufacturer</td>
<td></td>
</tr>
<tr>
<td>Door Position Switch</td>
<td>1</td>
<td>OT</td>
<td>by security contractor</td>
<td></td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 087113 - AUTOMATIC DOOR OPERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section Includes:
      1. Low-energy door operators for swinging doors.

1.3 DEFINITIONS
   A. AAADM: American Association of Automatic Door Manufacturers.
   B. Activation Device: A control that, when actuated, sends an electrical signal to the door operator to open the door.
   C. Safety Device: A control that, to avoid injury, prevents a door from opening or closing.
   D. For automatic door terminology, see BHMA A156.19 for definitions of terms.

1.4 COORDINATION
   A. Coordinate sizes and locations of recesses in concrete floors for recessed control mats that control automatic door operators. Concrete, reinforcement, and formwork requirements are specified elsewhere.
   B. Templates: Distribute for doors, frames, and other work specified to be factory prepared and reinforced for installing automatic door operators.
   C. Coordinate hardware for doors with operators to ensure proper size, thickness, hand, function, and finish.
   D. Electrical System Roughing-in: Coordinate layout and installation of automatic door operators with connections to power supplies.

1.5 ACTION SUBMITTALS
   A. Product Data: For each type of product.
      1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for automatic door operators.
      2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For automatic door operators.
   1. Include plans, elevations, sections, hardware mounting heights, and attachment details.
   2. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Indicate locations of activation and safety devices.
   4. Include diagrams for power, signal, and control wiring.

D. Samples: For each exposed product and for each color and texture specified, manufacturer's standard size.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For automatic door operators, safety devices, and control systems, to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer for installation and maintenance of units required for this Project.

B. Certified Inspector Qualifications: Certified by AAADM.

C. Provide the following upon request:
   1. Qualification Data: For Installer and Certified Inspector.
   2. Product Certificates: For each type of automatic door operator.
   3. Field quality-control reports.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of automatic door operators that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Faulty or sporadic operation of automatic door operator, including controls.
      b. Deterioration of metals, metal finishes, and other materials beyond normal weathering or use.
   2. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Besam Entrance Solutions; Subsidiary of ASSA ABLOY Entrance Systems.
   2. DORMA Automatics; Div. of DORMA Group North America.
3. Horton Automatics; a division of Overhead Door Corporation.
4. LCN Closers; an Ingersoll-Rand company.

B. Source Limitations: Obtain automatic door operators, including activation and safety devices, from single source from single manufacturer.

2.2 AUTOMATIC DOOR OPERATORS, GENERAL

A. General: Provide operators of size recommended by manufacturer for door size, weight, and movement; for condition of exposure; and for long-term, maintenance-free operation under normal traffic load for occupancy type indicated; and according to UL 325. Coordinate operator mechanisms with door operation, hinges, and activation and safety devices.

1. Emergency Breakaway: Where indicated for center-pivoted doors, provide emergency breakaway feature for reverse swing of doors. Equip system to discontinue power to automatic door operator when door is in emergency breakaway position, to return door to closed position after breakaway, and to automatically reset.

2. Wind Load: Provide door operators on exterior doors that will open and close doors and maintain them in fully closed position when subjected to wind load of <Insert wind load>.

B. Electromechanical Operating System: Self-contained unit powered by permanent-magnet dc motor; with closing speed controlled mechanically by gear train and dynamically by braking action of electric motor, connections for power and activation- and safety-device wiring, and manual operation including spring closing when power is off.

C. Hinges: See Section 087100 "Door Hardware" for hinge type for each door that door operator shall accommodate.

D. Housing for Overhead Concealed Operators: Fabricated from minimum 0.125-inch-thick, extruded or formed aluminum and extending full width of door opening including door jambs to conceal door operators and controls. Provide hinged or removable access panels for service and adjustment of door operators and controls. Secure panels to prevent unauthorized access.

E. Brackets and Reinforcements: Fabricated from aluminum with nonstaining, nonferrous shims for aligning system components.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 LOW-ENERGY DOOR OPERATORS

A. Standard: BHMA A156.19.

B. Performance Requirements:

1. Opening Force if Power Fails: Not more than 15 lbf required to release latch if provided, not more than 30 lbf required to manually set door in motion, and not more than 15 lbf required to fully open door.

2. Entrapment-Prevention Force: Not more than 15 lbf (67 N) required to prevent stopped door from closing or opening.

C. Configuration: Operator to control pair of swinging doors and single doors as indicated.


D. Operation: Power opening and power-assisted spring closing. Provide time delay for door to remain open before initiating closing cycle as required by BHMA A156.19. When not in automatic mode, door operator shall function as manual door closer, with or without electrical power.

E. Operating System: Electromechanical.

F. Microprocessor Control Unit: Solid-state controller.

G. Features:
   1. Adjustable opening and closing speed.
   2. Adjustable opening and closing force.
   3. Adjustable backcheck.
   4. Adjustable hold-open time from zero to 30 seconds.
   5. Adjustable time delay.
   6. Adjustable acceleration.
   7. Obstruction recycle.
   8. On-off/hold-open switch to control electric power to operator; key operated.

H. Activation Device: Push-plate switch on each side of door to activate door operator.

I. Exposed Finish: Finish matching door and frame.

2.4 MATERIALS

A. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
   1. Extrusions: ASTM B 221.

B. Fasteners and Accessories: Corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.

2.5 CONTROLS

A. General: Provide controls, including activation and safety devices, according to BHMA standards; for condition of exposure; and for long-term, maintenance-free operation under normal traffic load for occupancy type indicated. Coordinate activation and safety devices with door operation and door operator mechanisms.

B. Push-Plate Switch: Momentary-contact door control switch with flat push-plate actuator with contrasting-colored, engraved message.
   1. Configuration: Vertically-mounted, 36-inch-high, low profile, rectangular push plate with 2-by-4-inch junction box.
      a. Mounting: Surface mounted on wall on egress side of door opening, and pedestal mounted on entry side of door opening.
      b. Reference Standard: Meet or exceed CBC Section 1117B.6.
c. Basis-of-Design Product: Subject to compliance with requirements, provide Model No. LPR36 Low Profile Push Plate as manufactured by BEA, Inc., or Architect approved equal.


C. Electrical Interlocks: Unless units are equipped with self-protecting devices or circuits, provide electrical interlocks to prevent activation of operator when door is locked, latched, or bolted.

2.6 FABRICATION

A. Factory fabricate automatic door operators to comply with indicated standards.

B. Form aluminum shapes before finishing.

C. Fabricate exterior components to drain condensation and water passing joints within operator enclosure to the exterior.

D. Use concealed fasteners to greatest extent possible. Where exposed fasteners are required, use countersunk Phillips flat-head machine screws, finished to match operator.

2.7 ACCESSORIES

A. Signage: As required by cited BHMA standard for type of door and its operation.
   2. Provide sign materials with instructions for field application when operators are installed.

2.8 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying strippable, temporary protective covering before shipping.

B. Apply organic and anodic finishes to formed metal after fabrication unless otherwise indicated.

C. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances, door and frame preparation and reinforcements, and other conditions affecting performance of automatic door operators.

B. Examine roughing-in for electrical systems to verify actual locations of power connections before automatic door operator installation.
3.2 INSTALLATION

A. General: Install automatic door operators according to manufacturer’s written instructions and cited BHMA standard for type of door operation and direction of pedestrian travel, including signage, controls, wiring, remote power units if any, and connection to building’s power supply.

1. Do not install damaged components. Fit joints to produce hairline joints free of burrs and distortion.
2. Install operators true in alignment with established lines and door geometry without warp or rack. Anchor securely in place.

B. Controls: Install activation and safety devices according to manufacturer’s written instructions and cited BHMA standard for operator type and direction of pedestrian travel. Connect control wiring according to Division 26 section for "Low-Voltage Electrical Power Conductors and Cables."

C. Access-Control System: Connect operators to access-control system as specified in Division 28 section for "Access Control."

D. Signage: Apply on both sides of each door as required by cited BHMA standard for type of door operator and direction of pedestrian travel.

3.3 FIELD QUALITY CONTROL

A. Certified Inspector: Engage a Certified Inspector to test and inspect components, assemblies, and installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test and inspect each automatic door operator installation, using AADDM inspection forms, to determine compliance of installed systems with applicable BHMA standards.

C. Automatic door operators will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust automatic door operators to function smoothly, and lubricate as recommended by manufacturer; comply with requirements of applicable BHMA standards.

1. Adjust operators on exterior doors for weathertight closure.

B. After completing installation of automatic door operators, inspect exposed finishes on doors and operators. Repair damaged finish to match original finish.

C. Readjust automatic door operators and controls after repeated operation of completed installation equivalent to three days’ use by normal traffic (100 to 300 cycles).
D. Occupancy Adjustment: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train District's maintenance personnel to adjust, operate, and maintain automatic door operators.

END OF SECTION
SECTION 088000 – GLAZING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes glazing for the following products and applications, including those specified in other Sections where glazing requirements are specified by reference to this Section:
1. Windows.
2. Doors.
4. Storefront framing.
5. Glazed entrances.
6. Interior borrowed lites.

B. Related Work: Install glazing in the following assemblies
1. Section 084113 "Aluminum-Framed Entrances and Storefronts."
2. Section 084216 "Interior Aluminum Storefront Frames."
3. Section 084413 "Glazed Aluminum Curtain Walls" for glazing sealants.
4. Section 084423 "Structural-Sealant-Glazed Curtain Walls" for structural and glazing sealants.
5. Section 085113 "Miscellaneous Interior Aluminum Windows" for glazing system for pre-glazed aluminum transaction windows and u-channel aluminum framed glazing.

C. Related Requirements:
1. Section 088300 "Mirrors."
2. Section 088813 "Fire Resistant Glazing and Framing."

1.3 DEFINITIONS

A. Glass Manufacturers: Firms that produce primary glass, as defined in referenced glazing publications.

B. Glass Fabrication: Using primary glass in the production of single pane glass products such as coated, laminated and heat treated glass. Can be done by either the Glass Manufacturer or the Glazing Product Manufacturer.

C. Glazing Product Manufacturer: Firm that uses fabricated glass in the production of insulating glass (multiple panes of glass).

D. Glass Thicknesses: Indicated by thickness designations in millimeters according to ASTM C 1036.
E. Large Glass Lites and Insulating Glass Units: over 55 SF.

F. Interspace: Space between lites of a conventional insulating-glass unit.

1.4 PERFORMANCE REQUIREMENTS

A. General: Installed glazing systems shall withstand normal thermal movement and wind and impact loads (where applicable) without failure, including loss or glass breakage attributable to the following: defective manufacture, fabrication, or installation; failure of sealants or gaskets to remain watertight and airtight; deterioration of glazing materials; or other defects in construction.

B. Delegated Design: Design glass, including comprehensive engineering analysis according to ASTM E 1300 by a qualified professional engineer, using the following design criteria:

1. Design Wind Pressures: As indicated on Drawings.
2. Vertical Glazing: For glass surfaces sloped 15 degrees or less from vertical, design glass to resist design wind pressure based on glass type factors for short-duration load.
3. Probability of Breakage:
   a. For glass surfaces sloped no more than 15 degrees from vertical, design glass for a probability of breakage not greater than 0.008 (8 per 1000).
4. Maximum Lateral Deflection: For glass supported on all four edges, limit center-of-glass deflection at design wind pressure to not more than 1/50 times the short-side length or 1 inch, whichever is less.
5. Differential Shading: Design glass to resist thermal stresses induced by differential shading within individual glass lites.

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on glass framing members and glazing components.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

1.5 PRECONSTRUCTION TESTING

A. Preconstruction Adhesion and Compatibility Testing: Test each glazing material type, tape sealant, gasket, glazing accessory, and glass-framing member for adhesion to and compatibility with elastomeric glazing sealants.

1. Testing will not be required if data are submitted based on previous testing of current sealant products and glazing materials matching those submitted.
2. Use ASTM C 1087 to determine whether priming and other specific joint-preparation techniques are required to obtain rapid, optimum adhesion of glazing sealants to glass, tape sealants, gaskets, and glazing channel substrates.
3. Test no fewer than [eight] <Insert number> Samples of each type of material, including joint substrates, shims, sealant backings, secondary seals, and miscellaneous materials.
4. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
5. For materials failing tests, submit sealant manufacturer's written instructions for corrective measures including the use of specially formulated primers.

1.6 ACTION SUBMITTALS

A. Product Data: For each glass product and glazing material indicated.
B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings:
   1. Submit Shop Drawings of glazing details. Draw details at least full size (twice full size preferred) and indicate dimensions, tolerances and materials.
   2. Submit Shop Drawings for structural sealant glazing after review and approval of Shop Drawings by sealant and glass product manufacturers.

D. Glass Samples: With each submittal, submit a list of all glass Styles required in the Project. On the list, indicate which Styles are included in the submittal.
   1. Each style of monolithic and laminated glass, except clear monolithic glass, no less than 75 by 150 mm (3 by 6 inches).
   2. Each style of insulating and insulating laminated glass unit, no less than 300 by 300 mm (12 by 12 inches), including type of edge seal, spacer, and corner construction of spacer. Identify specific type of reflective and low-emissivity coated glasses, coated surfaces, and exterior face of unit.

E. Exposed Glazing Accessory Samples: For gaskets, sealants and colored spacers, in 12-inch lengths. Install sealant Samples between two strips of material representative in color of the adjoining framing system after sealant color selection has been made.

F. Other Glazing Accessory Samples:
   1. Compression wedge, 150 mm (6 inches) long.
   2. Channel gasket, 150 mm (6 inches) long.
   3. Bed gasket, 150 mm (6 inches) long.
   4. Setting block.
   5. Edge block.
   6. Compressible filler.

G. Glazing Schedule: List glass types and thicknesses for each size opening and location. Use same designations indicated on Drawings.

H. Delegated-Design Submittal: For glass indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

I. Preconstruction adhesion and compatibility test report.

J. Quality Assurance Program (QAP)
   1. Glass fabrication: Written QAP including but not limited to reference of applicable ASTM testing methodology, type and frequency of in-line monitoring of glass fabrication, and reporting and documentation. Test sample lite of glass, at GC’s expense, for conformance to a) bow and warp, b) localized distortion / roller wave, c) concavity / convexity and d) compression strength.
   2. Installation: Written QAP to monitor quality of products such as cleaners, solvents, primers, and sealants; and sealant workmanship including, cleaning, priming, joint opening preparation, and sealant installation.
      a. Include as part of program random adhesion and compatibility testing of production run products.
      b. Do not install sealant work prior to review of program.
      c. Submit quality assurance program to glass and sealant manufacturers for review and approval prior to submission to Architect.
1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs glass installers for this Project who are certified under the National Glass Association's Certified Glass Installer Program.

B. Glass Testing Agency Qualifications: A qualified independent testing agency accredited according to the NFRC CAP 1 Certification Agency Program.

C. Sealant Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated.

D. Source Limitations for Glass: Obtain ultraclear float glass, and coated float glass from single source from single manufacturer.

E. Source Limitations for Glass: Obtain laminated glass and insulating glass from single source from single manufacturer using primary glass obtained from a single source for each glass type.

F. Source Limitations for Glazing Accessories: Obtain from single source from single manufacturer for each product and installation method.

G. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below, unless more stringent requirements are indicated. Refer to these publications for glazing terms not otherwise defined in this Section or in referenced standards.

H. Safety Glazing Labeling: Where safety glazing labeling is indicated, permanently mark glazing with certification label of the SGCC or the SGCC or another certification agency acceptable to authorities having jurisdiction. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.
   1. All permanent marks and/or labels should be placed in the vicinity of the glass where the label is not obscured by the glass bite, gasket, sealant or other anchoring/glazing material. End text at least 3 mm from all site lines of the fenestration glazing to allow for readability.

I. Insulating-Glass Certification Program: Permanently marked either on spacers or on at least one component lite of units with appropriate certification label of IGCC.

J. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Install glazing in mockups specified in Division 08 Sections for "Aluminum-Framed Entrances and Storefronts," "Aluminum Windows," and "Glazed Curtain Walls" to match glazing systems required for Project, including glazing methods.
   2. Approved sample installation may become part of the completed Work if undisturbed at time of Substantial Completion.
   3. Place mockup where reflection from adjacent buildings or other structures with a regular pattern can be used to gauge overall appearance / distortion of the glass.
1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect glazing materials according to manufacturer's written instructions. Prevent damage to glass and glazing materials from condensation, temperature changes, direct exposure to sun, or other causes.

B. Comply with insulating-glass manufacturer's written recommendations for venting and sealing units to avoid hermetic seal ruptures due to altitude change.

1.9 PROJECT CONDITIONS

A. Environmental Limitations: Do not proceed with glazing when ambient and substrate temperature conditions are outside limits permitted by glazing material manufacturers and when glazing channel substrates are wet from rain, frost, condensation, or other causes.

1. Do not install glazing sealants when ambient and substrate temperature conditions are outside limits permitted by sealant manufacturer or below 40 deg F. Do not install sealants to wet or frost covered surfaces.

1.10 WARRANTY

A. General: During the warranty period, restore defective Work to the standard of the Contract Documents, including all labor, materials, refinishing and other costs incidental to the Work. Restore Work found to be defective as defined in the Contract Documents.

B. Manufacturer's Special Warranty for Coated-Glass Products: Manufacturer's standard form in which coated-glass manufacturer agrees to replace coated-glass units that deteriorate within specified warranty period. Deterioration of coated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning coated glass contrary to manufacturer's written instructions. Defects include peeling, cracking, and other indications of deterioration in coating.

1. Includes but not limited to fused ceramic spandrel, low-emissivity, and reflective glass.
2. Warranty Period: 10 years from date of Substantial Completion.

C. Manufacturer's Special Warranty on Laminated Glass: Manufacturer's standard form in which laminated-glass manufacturer agrees to replace laminated-glass units that deteriorate within specified warranty period. Deterioration of laminated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning laminated glass contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by referenced laminated-glass standard.

1. Includes but not limited to opacified spandrel glass.
2. Warranty Period: 10 years from date of Substantial Completion.

D. Manufacturer's Special Warranty on Insulating Glass: Manufacturer's standard form in which insulating-glass manufacturer agrees to replace insulating-glass units that deteriorate within specified warranty period. Deterioration of insulating glass is defined as failure of hermetic seal under normal use that is not attributed to glass breakage or to maintaining and cleaning insulating glass contrary to manufacturer's written instructions. Evidence of failure is the obstruction of vision by dust, moisture, or film on interior surfaces of glass.

1. Warranty Period: 10 years from date of Substantial Completion.
E. Installation: Glazing systems installation shall be warranted for a period of 5 years against defective materials and workmanship.

PART 2 - PRODUCTS

2.1 GLASS PRODUCTS, GENERAL

A. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass lites in thicknesses as needed to comply with requirements indicated.
   1. Minimum Glass Thickness for Exterior Lites: Not less than [6.0] <Insert thickness designation> mm.

B. Strength: Where float glass is indicated, provide Kind HS heat-treated float glass. For life safety or fire knock-out panel considerations, where fully tempered glass is indicated, provide Kind FT heat-treated fully tempered float glass.

C. Thermal and Optical Performance Properties: Provide glass with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated below:
   1. For monolithic-glass lites, properties are based on units with lites 6.0 mm thick.
   2. For laminated-glass lites, properties are based on products of construction indicated.
   3. For insulating-glass units, properties are based on units of thickness indicated for overall unit and for each lite.
   4. U-Factors: Center-of-glazing values, according to NFRC 100 and based on LBL's WINDOW 5.2 computer program, expressed as Btu/sq. ft. x h x deg F.
   5. Solar Heat-Gain Coefficient and Visible Transmittance: Center-of-glazing values, according to NFRC 200 and based on LBL's WINDOW 5.2 computer program.
   6. Visible Reflectance: Center-of-glazing values, according to NFRC 300.

D. Safety Glass
   1. CPSC 16 CFR part 1201, testing requirements of ANSI Z97.1, and listed in the SGCC Certified Products Directory with appropriate SGCC certification mark or label permanently affixed.
   2. Furnish safety glass for glass occurring in doors and sidelights, and where indicated and further required by authorities having jurisdiction.

2.2 GLASS PRODUCTS

A. Ultraclear Float Glass: ASTM C 1036, Type I, Quality-Q3, Class I, complying with other requirements specified and with visible light transmission not less than 91 percent and solar heat gain coefficient not less than 0.87; heat-treated as described below.
   1. Products: Subject to compliance with requirements, provide one of the following:
      b. Pilkington North America; Optiwhite.
      c. PPG Industries, Inc.; Starphire.

B. Heat-Treated Float Glass: ASTM C 1048; Type I; Quality-Q3; Class I (clear) unless otherwise indicated; of kind and condition indicated.
1. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as installed unless otherwise indicated.
2. For uncoated glass, comply with requirements for Condition A.
3. For coated vision glass, comply with requirements for Condition C (other coated glass).
4. Limit Kind HS surface compression to upper end of ASTM C 1048 range, 7,500 psi.
5. Distortion Tolerances:
   a. Roller Wave: Maximum 0.003 inch (0.076mm) from peak to valley within the main body of the sheet and maximum 0.008 inch (0.20mm) within 10.5 inches of a leading or trailing edge.
   b. Localized Warp: Maximum 0.03 inch (0.80mm) over any 12 inch (305mm) span, but limited to 0.31 inch (8.00mm).

   2. Ceramic Coating Color and Pattern: As selected by Architect from manufacturer's full range.

D. Mirror: Refer to Section 088300 "Mirrors."

E. Fire-Resistant Glazing: Refer to Section 088813 "Fire-Resistant Glazing and Framing."

2.3 LAMINATED GLASS

   A. Laminated Glass: ASTM C 1172, and complying with testing requirements in 16 CFR 1201 for Category II materials, and with other requirements specified. Use materials that have a proven record of no tendency to bubble, discolor, or lose physical and mechanical properties after fabrication and installation.
      1. Construction: Laminate glass with SentryGlas polymer interlayer as indicated to comply with interlayer manufacturer's written recommendations.
      2. Interlayer Thickness: Provide thickness not less than that indicated and as needed to comply with requirements.
      3. Interlayer Color: Clear and translucent pattern where indicated.
         a. Translucent Pattern: As selected by Architect.

   B. Glass: Comply with applicable requirements in "Glass Products" Article as indicated by designations in "Laminated-Glass Types" Article.

2.4 INSULATING GLASS

   A. Insulating-Glass Units: Factory-assembled units consisting of sealed lites of glass separated by a dehydrated interspace, qualified according to ASTM E 2190, and complying with other requirements specified.
      1. Listed in the IGCC/IGMA Certified Products Directory with appropriate Certification mark on the spacer or at least one pane of unit.
      2. Sealing System: Dual seal, with manufacturer's standard primary and secondary, and with soldered, welded, and/or bent spacer corner construction.
         a. Units for structural sealant glazing: dual seal construction of a polyisobutylene primary seal and silicone secondary seal, and with soldered, welded, and/or bent spacer corner construction.
3. Spacer: Manufacturer’s standard thermally-broken spacer material and construction.
4. Desiccant: Molecular sieve or silica gel, or blend of both.
5. Units which will be shipped through or glazed at altitudes of 1520 meters (5000 feet) or more above sea level, fabricated with breather or capillary tubes, to permit air space pressure equalization. Provide same warranty as for non-breather or capillary tube units. Pinch tubes during glazing if required by glass manufacturer.

B. Glass: Comply with applicable requirements in "Glass Products" Article as indicated by designations in "Insulating-Glass Types" Article.

2.5 GLAZING GASKETS

A. Dense Compression Gaskets: Molded or extruded gaskets of profile and hardness required to maintain watertight seal, compatible with glazing sealants, and made from one of the following:
   1. EPDM complying with ASTM C 864.
   2. Silicone complying with ASTM C 1115.
   3. Thermoplastic polyolefin rubber complying with ASTM C 1115.
   4. Compression wedge for dry glazing system: of shape and size to compress the exterior compression gasket a minimum of 25 percent, and as recommended by glazing and sealing systems manufacturer.

B. Soft Compression Gaskets: Extruded or molded, closed-cell, integral-skinned EPDM, silicone or thermoplastic polyolefin rubber gaskets complying with ASTM C 509, Type II, black; of profile and hardness required to maintain watertight seal.
   1. Bed gasket for wet glazing system: continuous with pressure sensitive adhesive 1 side, designed to be compressed 25-40 percent in the opening.
   2. Compression gasket for dry glazing system: shape as required to be compressed in place a minimum of 25 percent and of one-piece construction with factory-assembled frames with injection-molded, vulcanized corners; produced oversize in opening dimension, as determined by measurements, to insure compression at corners but within limits so that compression does not create a "pucker".
   3. Channel gasket: continuous channel of shape and dimensions for application in the opening with specified glazing.

2.6 GLAZING SEALANTS

A. General:
   1. Compatibility: Provide glazing sealants that are compatible with one another and with other materials they will contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
   2. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.
   3. VOC Content: For sealants used inside of the weatherproofing system, not more than 250 g/L when calculated according to 40 CFR 59, Subpart D.
   4. Colors of Exposed Glazing Sealants: As selected by Architect from manufacturer's full range.

B. Glazing Sealant: Neutral-curing silicone glazing sealant complying with ASTM C 920, Type S, Grade NS, Class 100/50, Use NT.
1. **Products:** Subject to compliance with requirements, provide one of the following:
   a. Dow Corning Corporation; 790.
   b. GE Advanced Materials - Silicones; SilPruf LM SCS2700.
   d. Sika Corporation, Construction Products Division; SikaSil-C990.
   e. Tremco Incorporated; Spectrem 1.

C. **Glazing Sealant:** Neutral-curing silicone glazing sealant complying with ASTM C 920, Type S, Grade NS, Class 50, Use NT.
   1. **Products:** Subject to compliance with requirements, provide one of the following:
      a. Dow Corning Corporation; 791 or 795.
      b. GE Advanced Materials - Silicones; SilGlaze II SCS2800.
      d. Sika Corporation, Construction Products Division; SikaSil-C995.
      e. Tremco Incorporated; Spectrem 2 or Spectrem 3.

D. See Division 8 STRUCTURAL-SEALANT-GLAZED CURTAIN WALLS for information on structural sealant.

2.7 **MISCELLANEOUS GLAZING MATERIALS**

A. **General:** Provide products of material, size, and shape complying with referenced glazing standard, requirements of manufacturers of glass and other glazing materials for application indicated, and with a proven record of compatibility with surfaces contacted in installation.

B. **Cleaners, Primers, and Sealers:** Types recommended by sealant or gasket manufacturer.

C. **Setting Blocks:** Elastomeric material with a Shore, Type A durometer hardness of 85, plus or minus 5.
   1. Each block shall be properly sized for load, as wide or wider than glazing, no less than 4 inches long; profile to permit friction fit, dart insertion into metal chair, or pressure sensitive adhesive one side to fix block in glazing opening.

D. **Spacers:** Elastomeric blocks or continuous extrusions of 40 to 60 Shore "A" durometer hardness to maintain glass lites in place for installation indicated.
   1. Profile to permit friction fit, dart insertion or pressure sensitive adhesive one side to fix shim or spacer in location.

E. **Edge Blocks:** Elastomeric material of 40 to 60 Shore "A" durometer hardness to limit glass lateral movement (side walking).
   1. Each block shall be a minimum 4 inches long, as wide as glazing, placed in the vertical glazing channel, and sized to allow a nominal 1/8-inch clearance between glass edge and installed block; profile to permit friction fit or pressure sensitive adhesive one side to fix block in glazing opening.

F. **Cylindrical Glazing Sealant Backing:** ASTM C 1330, Type O (open-cell material), of size and density to control glazing sealant depth and otherwise produce optimum glazing sealant performance.

G. **Open Cell Filter**
1. Reticulated flexible polyester urethane foam having 20 pores per inch, sized at least 25 mm (1 inch) larger in dimension than weep hole, of cross section to provide 15 to 25 percent compression for friction fit and as manufactured by Foam Division, Scott Paper Co.; H-O Products Corp.; or as approved.

H. Bond Breaker
1. Heavy duty, 0.28-mm (11-mil) minimum thickness, colored, polyethylene or teflon, self-adhesive bond breaker of type recommended by sealant manufacturer and suitable for conditions of usage. Liquid bond breaker is not permitted.

2.8 FABRICATION OF GLAZING UNITS

A. Fabricate glazing units in sizes required to fit openings indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer and referenced glazing publications, to comply with system performance requirements.

B. Clean-cut or flat-grind vertical edges of butt-glazed monolithic lites to produce square edges with slight chamfers at junctions of edges and faces.

C. Grind smooth and polish exposed glass edges and corners.

2.9 LAMINATED-GLASS TYPES

A. Glass Type IGL-1T: Clear laminated glass with two plies of ultraclear fully tempered float glass.
   1. Thickness of Each Glass Ply: 6.0 mm.
   2. Interlayer Thickness and Type: 0.060 inch PVB clear.
   3. Provide safety glazing labeling.

B. Glass Type IGL-2T: Clear laminated glass with two plies of ultraclear fully tempered float glass with full patterned interlayer.
   1. Thickness of Each Glass Ply: 6.0 mm.
   2. Interlayer Thickness and Type: 0.030 inch PVB decorative translucent pattern.
      a. Color and Opacity: As indicated on Drawings.
   3. Provide safety glazing labeling.

C. Glass Type IGL-3T: Clear laminated glass with two plies of ultraclear fully tempered float glass with patterned interlayer.
   1. Thickness of Each Glass Ply: 6.0 mm.
   2. Interlayer Thickness and Type: 0.030 inch PVB decorative clear and translucent spliced pattern as shown.
      a. Color and Opacity: As indicated on Drawings.
   3. Provide safety glazing labeling.

2.10 INSULATING-GLASS TYPES

A. Glass Type EGL-1: Low-e-coated, clear insulating glass.
1. Overall Unit Thickness: 1 inch.
2. Thickness of Each Glass Lite: 6.0 mm.
4. Interspace Content: Argon.
5. Indoor Lite: Heat-strengthened float glass.
7. Basis-of-Design Product: Vitro Solarban 70XL

B. Glass Type EGL-1T: Low-e-coated, clear insulating safety glass.
1. Overall Unit Thickness: 1 inch.
2. Thickness of Each Glass Lite: 6.0 mm.
3. Outdoor Lite: Fully tempered float glass.
4. Interspace Content: Argon.
5. Indoor Lite: Fully tempered float glass.
7. Provide safety glazing labeling.
8. Basis-of-Design Product: Vitro Solarban 70XL, Tempered

C. Glass Type EGL-2: Low-e-coated, ultraclear insulating glass.
1. Overall Unit Thickness: 1 inch.
2. Thickness of Each Glass Lite: 6.0 mm.
4. Interspace Content: Air.
5. Indoor Lite: Ultraclear fully tempered float glass.
7. Basis-of-Design Product: Vitro Solarban 90

D. Glass Type EGL-2S: Low-e-coated, ultraclear insulating glass.
1. Overall Unit Thickness: 1 inch.
2. Thickness of Each Glass Lite: 6.0 mm.
4. Interspace Content: Air.
5. Indoor Lite: Ultraclear fully tempered float glass.
7. Basis-of-Design Product: Vitro Solarban 90 Shadow Box

E. Glass Type EGL-2T: Low-e-coated, ultraclear insulating safety glass.
1. Overall Unit Thickness: 1 inch.
2. Thickness of Each Glass Lite: 6.0 mm.
3. Outdoor Lite: Ultraclear fully tempered float glass.
4. Interspace Content: Air.
5. Indoor Lite: Ultraclear fully tempered float glass.
7. Provide safety glazing labeling.
8. Basis-of-Design Product: Vitro Solarban 90, Tempered

F. Glass Type EGL-3T: Ceramic-coated, low-e, insulating safety glass.
1. Overall Unit Thickness: 1 inch.
2. Thickness of Each Glass Lite: 6.0 mm.
3. Outdoor Lite: Fully tempered float glass.
4. Interspace Content: Air.
5. Indoor Lite: Ultraclear fully tempered float glass.
7. Coating Location: Third surface.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine framing, glazing channels, and stops, with Installer present, for compliance with the following:
   1. Manufacturing and installation tolerances, including those for size, squareness, and offsets at corners.
   2. Presence and functioning of weep systems.
   3. Minimum required face and edge clearances.
   4. Effective sealing between joints of glass-framing members.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean glazing channels and other framing members receiving glass immediately before glazing. Remove coatings not firmly bonded to substrates.

B. Examine glazing units to locate exterior and interior surfaces. Label or mark units as needed so that exterior and interior surfaces are readily identifiable. Do not use materials that will leave visible marks in the completed work.

3.3 GLAZING, GENERAL

A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.
   1. Ensure approved Quality Assurance Program is implemented.

B. Adjust glazing channel dimensions as required by Project conditions during installation to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances.

C. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass is glass with edge damage or other imperfections that, when installed, could weaken glass and impair performance and appearance.

D. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.

E. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.
1. Locate one quarter of glass width from each corner, but with block edge nearest corner no closer than 150 mm (6 inches) from corner, unless otherwise specified or required by glass manufacturer.

2. Insulating glass used in sloped glazing shall have both panes supported by setting blocks.

F. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.

G. Provide spacers for glass lites where length plus width is larger than 50 inches.
   1. Locate spacers directly opposite each other on both inside and outside faces of glass. Install correct size and spacing to preserve required face clearances, unless gaskets and glazing tapes are used that have demonstrated ability to maintain required face clearances and to comply with system performance requirements.
   2. Provide 1/8-inch minimum bite of spacers on glass and use thickness equal to sealant width. With glazing tape, use thickness slightly less than final compressed thickness of tape.

H. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and according to requirements in referenced glazing publications.

I. Set glass lites in each series with uniform pattern, draw, bow, and similar characteristics.

J. Set glass lites with proper orientation so that coatings face exterior or interior as specified.

K. Where wedge-shaped gaskets are driven into one side of channel to pressurize sealant or gasket on opposite side, provide adequate anchorage so gasket cannot walk out when installation is subjected to movement.

L. Square cut wedge-shaped gaskets at corners and install gaskets in a manner recommended by gasket manufacturer to prevent corners from pulling away; seal corner joints and butt joints with sealant recommended by gasket manufacturer.

3.4 GASKET GLAZING (DRY)

A. Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.

B. Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.

C. Installation with Drive-in Wedge Gaskets: Center glass lites in openings on setting blocks and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.

D. Installation with Pressure-Glazing Stops: Center glass lites in openings on setting blocks and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.
E. Install gaskets so they protrude past face of glazing stops.

3.5 SEALANT GLAZING (WET)

A. Install continuous spacers, or spacers combined with cylindrical sealant backing, between glass lites and glazing stops to maintain glass face clearances and to prevent sealant from extruding into glass channel and blocking weep systems until sealants cure. Secure spacers or spacers and backings in place and in position to control depth of installed sealant relative to edge clearance for optimum sealant performance.

B. Force sealants into glazing channels to eliminate voids and to ensure complete wetting or bond of sealant to glass and channel surfaces.

C. Tool exposed surfaces of sealants to provide a substantial wash away from glass.

3.6 CLEANING AND PROTECTION

A. Protect exterior glass from damage immediately after installation by attaching crossed streamers to framing held away from glass. Do not apply markers to glass surface. Remove nonpermanent labels and clean surfaces.

B. Protect glass from contact with contaminating substances resulting from construction operations. If, despite such protection, contaminating substances do come into contact with glass, remove substances immediately as recommended in writing by glass manufacturer.

C. Remove and replace glass that is broken, chipped, cracked, or abraded or that is damaged from natural causes, accidents, and vandalism, during construction period.

D. Wash glass on both exposed surfaces in each area of Project not more than four days before date scheduled for inspections that establish date of Substantial Completion. Wash glass as recommended in writing by glass manufacturer.

END OF SECTION
SECTION 088300 - MIRRORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following types of silvered flat glass mirrors:
   1. Tempered glass mirrors qualifying as safety glazing.

B. Related Requirements:
   1. Section 088000 "Glazing" for glass with reflective coatings used for vision and spandrel lites.
   2. Section 102800 "Toilet, Bath, and Laundry Accessories" for metal-framed mirrors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Mirrors. Include description of materials and process used to produce each type of silvered flat glass mirror specified that indicates sources of glass, glass coating components, edge sealer, and quality-control provisions.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Include mirror elevations, edge details, mirror hardware, and attachment details.

D. Samples: For each type of the following:
   1. Mirrors: 12 inches square, including edge treatment on two adjoining edges.

1.4 QUALITY ASSURANCE

A. Provide the following upon request:
   1. Qualification Data: For Installer.
   2. Product Certificates: For each type of mirror and mirror mastic.
   3. Preconstruction Test Reports: From mirror manufacturer indicating that mirror mastic was tested for compatibility and adhesion with mirror backing and substrates on which mirrors are installed.
1.5 PRECONSTRUCTION TESTING

A. Preconstruction Mirror Mastic Compatibility Test: Submit mirror mastic products to mirror manufacturer for testing to determine compatibility of mastic with mirror backing.
   1. Testing is not required if data are submitted based on previous testing of mirror mastic products and mirror backing matching those submitted.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect mirrors according to mirror manufacturer's written instructions and as needed to prevent damage to mirrors from moisture, condensation, temperature changes, direct exposure to sun, or other causes.

B. Comply with mirror manufacturer's written instructions for shipping, storing, and handling mirrors as needed to prevent deterioration of silvering, damage to edges, and abrasion of glass surfaces and applied coatings. Store indoors.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Do not install mirrors until ambient temperature and humidity conditions are maintained at levels indicated for final occupancy.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to replace mirrors that deteriorate within specified warranty period. Deterioration of mirrors is defined as defects developed from normal use that are not attributed to mirror breakage or to maintaining and cleaning mirrors contrary to manufacturer's written instructions. Defects include discoloration, black spots, and clouding of the silver film.
   1. Warranty Period: Five years from date of [Substantial Completion] [manufacture].

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations for Mirrors: Obtain mirrors from single source from single manufacturer.

B. Source Limitations for Mirror Accessories: Obtain mirror glazing accessories from single source.

2.2 SILVERED FLAT GLASS MIRRORS

A. Mirrors, General: ASTM C 1503; manufactured using copper-free, low-lead mirror coating process.

B. Tempered Glass Mirrors: Mirror Glazing Quality for blemish requirements and complying with ASTM C 1048 for Kind FT, Condition A, tempered float glass before silver coating is applied; clear.
1. Nominal Thickness: 6.0 mm.

C. Safety Glazing Products: For tempered mirrors, provide products that comply with 16 CFR 1201, Category II.

2.3 MISCELLANEOUS MATERIALS

A. Setting Blocks: Elastomeric material with a Shore, Type A durometer hardness of 85, plus or minus 5.

B. Edge Sealer: Coating compatible with glass coating and approved by mirror manufacturer for use in protecting against silver deterioration at mirrored glass edges.

C. Mirror Mastic: An adhesive setting compound, asbestos-free, produced specifically for setting mirrors and certified by both mirror and mastic manufacturer as compatible with glass coating and substrates on which mirrors will be installed.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Franklin International.
   b. Laurence, C. R. Co., Inc.
   c. Liquid Nails Adhesive.
   d. Palmer Products Corporation.
   e. Royal Adhesives & Sealants, LLC.

2. Adhesive shall have a VOC content of 70 g/L or less.

2.4 MIRROR HARDWARE

A. Aluminum J-Channels and Cleat: Aluminum extrusions with a return deep enough to produce a glazing channel to accommodate mirrors of thickness indicated and in lengths required to cover edges of mirrors in a single piece.

1. Bottom Trim: J-channels formed with front leg and back leg not less than 5/16 and 3/4 inch in height, respectively.
2. Top Trim: Formed with front leg with a height matching bottom trim and back leg designed to fit into the pocket created by wall-mounted aluminum cleat.

B. Fasteners: Fabricated of same basic metal and alloy as fastened metal and matching it in finished color and texture where fasteners are exposed.

C. Anchors and Inserts: Provide devices as required for mirror hardware installation. Provide toothed or lead-shield, expansion-bolt devices for drilled-in-place anchors. Provide galvanized anchors and inserts for applications on inside face of exterior walls and where indicated.

2.5 FABRICATION

A. Fabricate mirrors in the shop to greatest extent possible.

B. Fabricate cutouts for notches and holes in mirrors without marring visible surfaces. Locate and size cutouts so they fit closely around penetrations in mirrors.
C. Mirror Edge Treatment: Flat polished.
   1. Seal edges of mirrors with edge sealer after edge treatment to prevent chemical or atmospheric penetration of glass coating.
   2. Require mirror manufacturer to perform edge treatment and sealing in factory immediately after cutting to final sizes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, over which mirrors are to be mounted, with Installer present, for compliance with installation tolerances, substrate preparation, and other conditions affecting performance of the Work.

B. Verify compatibility with and suitability of substrates, including compatibility of existing finishes or primers with mirror mastic.

C. Proceed with installation only after unsatisfactory conditions have been corrected and surfaces are dry.

3.2 PREPARATION

A. Comply with mastic manufacturer's written installation instructions for preparation of substrates, including coating substrates with mastic manufacturer's special bond coating where applicable.

3.3 INSTALLATION

A. General: Install mirrors to comply with mirror manufacturer's written instructions and with referenced GANA publications. Mount mirrors accurately in place in a manner that avoids distorting reflected images.

B. Provide a minimum airspace of 1/8 inch between back of mirrors and mounting surface for air circulation between back of mirrors and face of mounting surface.

C. Install mirrors with mastic and mirror hardware. Attach mirror hardware securely to mounting surfaces with mechanical fasteners installed with anchors or inserts as applicable. Install fasteners so heads do not impose point loads on backs of mirrors.
   1. Aluminum J-Channels and Cleat: Fasten J-channel directly to wall and attach top trim to continuous cleat fastened directly to wall.
   2. Install mastic as follows:
      a. Apply mastic to comply with mastic manufacturer's written instructions for coverage and to allow air circulation between back of mirrors and face of mounting surface.
3.4 CLEANING AND PROTECTION

A. Protect mirrors from breakage and contaminating substances resulting from construction operations.

B. Do not permit edges of mirrors to be exposed to standing water.

C. Maintain environmental conditions that prevent mirrors from being exposed to moisture from condensation or other sources for continuous periods of time.

D. Clean exposed surface of mirrors not more than four days before date scheduled for inspections that establish date of Substantial Completion. Clean mirrors as recommended in writing by mirror manufacturer.

END OF SECTION
SECTION 088813 - FIRE-RESISTANT GLAZING AND FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Fire-resistance-rated glazing and interior aluminum fire-rated frames.

1.3 DEFINITIONS

A. Glass Manufacturers: Firms that produce primary glass, fabricated glass, or both, as defined in referenced glazing publications.

B. Glass Thicknesses: Indicated by thickness designations in millimeters according to ASTM C 1036.

1.4 COORDINATION

A. Coordinate glazing channel dimensions to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings:
   1. Include plans, elevations and details of fire-rated framing product showing component dimensions; framing opening requirements, dimensions, tolerances, and attachment to structure

D. Glass Samples: For each type of glass product; 12 inches square.

E. Glazing Schedule: List glass types and thicknesses for each size opening and location. Use same designations indicated on Drawings.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs glass installers for this Project who are certified under the National Glass Association's Certified Glass Installer Program.
B. Testing Agency Qualifications: Qualifications according to
   1. International Accreditation Service for a Type A Third-Party Inspection Body (Field Services ICC-ES Third-Party Inspections Standard Operating Procedures, 00-BL-S0400 and S0401)
   2. International Accreditation Service for Testing Body-Building Materials and Systems
      a. Fire Testing
         1) ASTM Standards E 119
         2) CPSC Standards 16 CFR 1201
         3) NFPA Standards 251, 252, 257
         4) UL Standards 9, 10B, 10C, 1784, UL Subject 63

C. Fire-Rated Wall Assemblies: Assemblies complying with ASTM E119 that are classified and labeled by UL, for fire ratings indicated, based on testing in accordance with UL 263, ASTM E119.

D. Listings and Labels - Fire Rated Assemblies: Under current follow-up service by Underwriters Laboratories (ULI) maintaining a current listing or certification. Label assemblies accordance with limits of manufacturer's listing.

E. Provide the following upon request:
   1. Qualification Data: For installers.
   2. Product Certificates: For each type of glass and glazing product, from manufacturer.
   3. Test reports for fire-rating listing of glass, frame, and wall assemblies.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect glazing materials according to manufacturer's written instructions. Prevent damage to glass and glazing materials from condensation, temperature changes, direct exposure to sun, or other causes.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Do not deliver or install fire-resistant glazing until spaces are enclosed and weathertight and temporary HVAC system is operating and maintaining ambient temperature conditions at occupancy levels during the remainder of the construction period.

1.9 WARRANTY

A. Manufacturer's Special Warranty on Laminated Glass: Manufacturer agrees to replace laminated-glass units that deteriorate within specified warranty period. Deterioration of laminated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning laminated glass contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by referenced laminated-glass standard.
   1. Warranty Period: Five years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations for Glass and Framing: Obtain glass and framing from single source.

B. Source Limitations for Glazing Accessories: Obtain from single source from single manufacturer for each product and installation method.

2.2 PERFORMANCE REQUIREMENTS

A. General: Installed glazing systems shall withstand normal thermal movement and impact loads (where applicable) without failure, including loss or glass breakage attributable to the following: defective manufacture, fabrication, or installation; deterioration of glazing materials; or other defects in construction.

B. Delegated design: For the performance requirements listed below requiring structural design provide data, calculations and drawings signed and sealed by an engineer licensed in the state where the project is located.

C. System Description:
   1. Steel fire-rated glazed wall and/or window system, dual aluminum cover cap format
   2. Face width: 2-inch:
   3. Custom extruded aluminum cover caps
   4. Duration - Walls: Capable of providing a fire rating for 120 minutes.

D. Member deflection is referenced from the IBC Section 24 General Requirements for Glass, article 2403.3.

E. Design Requirements
   1. Design and size the system to withstand structural forces placed upon it without damage or permanent set when tested in accordance with ASTM E330 using load 1.5 times the design loads and of 10 seconds in duration at +/- 10 PSF.

2.3 GLASS PRODUCTS, GENERAL

A. Glazing Publications: Comply with published recommendations of glass product manufacturers and organization below unless more stringent requirements are indicated. Refer to these publications for glazing terms not otherwise defined in this Section or in referenced standards.

B. Safety Glazing Labeling: Permanently mark glazing with certification label of the Safety Glazing Certification Council or another certification agency acceptable to authorities having jurisdiction. Label shall indicate manufacturer's name, type of glass, glass thickness, and safety glazing standard with which glass complies.
2.4 FIRE-RESISTANCE-RATED GLAZING AND FRAMING

A. Fire-Resistance-Rated Glazing: Listed and labeled by a testing agency acceptable to authorities having jurisdiction, for fire-resistance ratings indicated, based on testing according to ASTM E 119 or UL 263.

1. Fire-Resistance-Rated Glazing Labeling: Permanently mark fire-resistance-rated glazing with certification label of a testing agency acceptable to authorities having jurisdiction. Label shall indicate manufacturer's name, test standard, that the glazing is approved for use in walls, and the fire-resistance rating in minutes.

B. Laminated Glass with Intumescent Interlayers, Type IGL-4: Low-iron clear laminated glass made from multiple plies of uncoated, ultraclear float glass; with intumescent interlayers; and complying with 16 CFR 1201, Category II.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Pilkington Pyrostop No 60-201 fire-rated butt glazing as manufactured by Pilkington Group and distributed by Technical Glass Products, or comparable by one of the following:
   a. InterEdge Technologies by AGC Flat Glass; Pyrobel.
   b. Vetrotech Saint-Gobain; SGG Contraflam.

2. Properties:
   a. Fire Rating: 60 minutes
   b. Nominal Thickness: 1-1/16-inch
   c. Weight: 12.9 psf
   d. U-Value: 0.83
   e. Daylight Transmission: 86 percent
   f. STC Rating: 44
   g. Vertical Butt Joint, Width: 5 mm (3/16-inch)

3. Label: Each piece of fire-rated glazing shall be labeled with a permanent logo including name of product, manufacture, testing laboratory (UL), fire rating period, safety glazing standards, and date of manufacture.

C. Frame System:

1. Basis-of-Design Products, Type IWS-3: Subject to compliance with requirements, provide Fireframes Clearview Series fire-rated butt-glazed frame system as manufactured and supplied by Technical Glass Products, or Architect approved equal.
   a. Material: Aluminum. Hollow metal steel is not acceptable.
   b. Frame system shall be same fire rating as glass and shall be a tested, listed, and labeled assembly.

2.5 GLAZING ACCESSORIES

A. Provide manufacturer's standard glazing gaskets, glazing sealants, glazing tapes, setting blocks, spacers, edge blocks, and other glazing accessories that are compatible with glazing products and each other and are approved by testing agencies that listed and labeled fire-resistant glazing products with which products are used for applications and fire-protection ratings indicated.

1. Glazing Tape: Closed cell polyvinyl chloride foam, coiled on release paper over adhesive on two sides, maximum water absorption by volume of 2 percent, designed for compression of 25 percent to effect an air and vapor seal.

2. Butt Glazing Silicone Sealant: For the butt glazing assembly, silicone sealant shall be applied to seal the butt joint. The sealant shall be provided by the glass manufacturer.
3. Butt Glazing Intumescent Strip: For the butt glazing assembly, 9/16 inch wide by 3/16 inch thick tape, shall be installed along the vertical edges of the sections of glass at the butt joint.
4. Setting Blocks: Hardwood or calcium silicate; glass width by 4 inches by 3/16 inch thick.
5. Spacers: Neoprene or other resilient blocks of 40 to 50 Shore A durometer hardness, adhesive-backed on one face only, tested for compatibility with specified glazing compound.

2.6 MISCELLANEOUS GLAZING MATERIALS

A. General: Provide products of material, size, and shape complying with referenced glazing standard, requirements of manufacturers of glass and other glazing materials for application indicated, and with a proven record of compatibility with surfaces contacted in installation.

B. Perimeter Insulation for Fire-Resistive Glazing: Product that is approved by testing agency that listed and labeled fire-resistant glazing product with which it is used for application and fire-protection rating indicated.

C. Cleaners, Primers, and Sealers: Type recommended by manufacturer of glass and gaskets.

D. Bituminous Paint: Cold-applied, asphalt-mastic paint complying with SSPC-Paint 12 requirements except containing no asbestos; formulated for 30-mil thickness per coat.

2.7 FABRICATION OF GLAZING UNITS

A. Fabricate glazing units in sizes required to fit openings indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer and referenced glazing publications, to comply with system performance requirements.

2.8 FINISHES, GENERAL

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.9 ALUMINUM FINISHES

A. Finish after fabrication.

B. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine framing, glazing channels, and stops, with Installer present, for compliance with manufacturing and installation tolerances, including those for size, squareness, and offsets at corners, and for compliance with minimum required face and edge clearances.

B. Examine substrates and members to which the work of this section attaches or adjoins prior to frame installation are acceptable for product installation in accordance with manufacturer's instructions. Provide openings plumb, square and within allowable tolerances. The manufacturer recommends 3/8 inch shim space at connection with perimeter walls.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean glazing channels and other framing members receiving glass immediately before glazing. Remove coatings not firmly bonded to substrates.

B. Examine glazing units to locate fire side and protected side. Label or mark units as needed so that fire side and protected side are readily identifiable. Do not use materials that leave visible marks in the completed work.

C. Examine framing components for dents, scratches, and other problems with framing or finish that may deter from finish product installation.

3.3 FRAMING INSTALLATION

A. Install framing in accordance with framing manufacturer’s written instructions to produce work meeting performance and workmanship requirements specified. Use methods approved by testing agencies that listed and labeled fire-resistant framing products.

3.4 GLAZING, GENERAL

A. Use methods approved by testing agencies that listed and labeled fire-resistant glazing products.

B. Comply with combined written instructions of manufacturers of glass, framing, sealants, gaskets, and other glazing materials unless more stringent requirements are indicated, including those in referenced glazing publications.

C. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass is glass with edge damage or other imperfections that, when installed, could weaken glass and impair performance and appearance.

D. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.
E. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.

F. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.

G. Provide spacers for glass lites where length plus width is larger than 50 inches.
   1. Locate spacers directly opposite each other on both inside and outside faces of glass. Install correct size and spacing to preserve required face clearances unless gaskets and glazing tapes are used that have demonstrated ability to maintain required face clearances and to comply with system performance requirements.
   2. Provide 1/8-inch minimum bite of spacers on glass and use thickness equal to sealant width. With glazing tape, use thickness slightly less than final compressed thickness of tape.

H. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and according to requirements in referenced glazing publications.

I. Set glass lites with proper orientation so that coatings face fire side or protected side as specified.

J. Where wedge-shaped gaskets are driven into one side of channel to pressurize sealant or gasket on opposite side, provide adequate anchorage so gasket cannot walk out when installation is subjected to movement.

K. Square cut wedge-shaped gaskets at corners and install gaskets in a manner recommended by gasket manufacturer to prevent corners from pulling away; seal corner joints and butt joints with sealant recommended by gasket manufacturer.

3.5 REPAIR AND TOUCH UP

A. Powder Coated Finishes
   1. Limited to minor repair of small scratches. Use only manufacturer’s recommended products.
   2. Such repairs shall match original finish for quality or material and view.
   3. Repairs and touch-up not visible from a distance of 5 feet Owner and Architect to approve.

B. Remove and replace glass that is broken, chipped, cracked, abraded, or damaged.

3.6 CLEANING AND PROTECTION

A. Immediately after installation, remove nonpermanent labels and clean surfaces.

B. Protect glass from contact with contaminating substances resulting from construction operations. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains.
   1. If, despite such protection, contaminating substances do come into contact with glass, remove substances immediately as recommended in writing by glass manufacturer.
C. Remove and replace glass that is damaged during construction period.

D. Wash glass on both exposed surfaces in each area of Project not more than four days before date scheduled for inspections that establish date of Substantial Completion. Wash glass as recommended in writing by glass manufacturer.

END OF SECTION
SECTION 089119 - FIXED LOUVERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Fixed extruded-aluminum louvers.
   2. Blank-off panels for louvers

1.3 DEFINITIONS

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.

B. Horizontal Louver: Louver with horizontal blades (i.e., the axis of the blades are horizontal).

C. Wind-Driven-Rain-Resistant Louver: Louver that provides specified wind-driven-rain performance, as determined by testing according to AMCA 500-L.

1.4 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 080413.

B. Product Data: For each type of product.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.
   1. Show weep paths, gaskets, flashings, sealants, and other means of preventing water intrusion.
   2. Show mullion profiles and locations.

E. Samples: For each type of metal finish required.

F. Delegated-Design Submittal: For louvers indicated to comply with structural and seismic performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1.5 QUALITY ASSURANCE

A. Provide the following upon request:
   1. Product Test Reports: Based on evaluation of comprehensive tests performed according to AMCA 500-L by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.
   2. Welding certificates.

1.6 FIELD CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

1.7 WARRANTY

A. Special Finish Warranty: Manufacturer agrees to repair or replace components on which finishes fail in materials or workmanship within specified warranty period.
   1. Deterioration includes, but is not limited to, the following:
      a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.
      b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
      c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
   2. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain fixed louvers from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design louvers, including comprehensive engineering analysis by a qualified professional engineer, using structural and seismic performance requirements and design criteria indicated.

B. Structural Performance: Louvers shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver-blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.
   1. Wind Loads: Determine loads based on pressures as indicated on Drawings.

C. Seismic Performance: Louvers, including attachments to other construction, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
D. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width according to AMCA 500-L.

E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.


2.3 FIXED EXTRUDED-ALUMINUM LOUVERS

A. Horizontal, Wind-Driven-Rain-Resistant Louver:
   1. Basis-of-Design Products: Subject to compliance with requirements, provide Model SCH601 as manufactured by Airolite Company, LLC (The), or comparable by one of the following:
      a. Construction Specialties, Inc.
      b. Greenheck Fan Corporation.
      c. Nystrom, Inc.
      d. Ruskin Company.
   2. Louver Depth: 6 inches.
   3. Frame and Blade Nominal Thickness: Not less than 0.080 inch.
   4. Louver Performance Ratings:
      a. Free Area: Not less than 7.0 sq. ft. for 48-inch- wide by 48-inch- high louver.
      b. Wind-Driven Rain Performance: Not less than 99 percent effectiveness when subjected to a rainfall rate of 8 inches per hour and a wind speed of 50 mph at a core-area air velocity of 600 fpm.
   5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.4 MATERIALS

A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5, T-52, or T6.

B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005, with temper as required for forming, or as otherwise recommended by metal producer for required finish.

C. Fasteners: Use types and sizes to suit unit installation conditions.
   1. For fastening aluminum, use aluminum or 300 series stainless-steel fasteners.
   2. For color-finished louvers, use fasteners with heads that match color of louvers.

D. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187/D 1187M.

E. Recycled Content of Aluminum Components: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 50 percent.

F. Regional Materials: Products shall be manufactured within 100 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.
2.5  FABRICATION

A. Factory assemble louvers to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.
   1. Continuous Vertical Assemblies: Fabricate units without interrupting blade-spacing pattern where indicated.
   2. Horizontal Mullions: Provide horizontal mullions at joints where indicated.

C. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.

D. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
   1. Frame Type: Interior flange unless otherwise indicated.

E. Include supports, anchorages, and accessories required for complete assembly.

F. Provide vertical mullions of type and at spacings indicated, but not more than is recommended by manufacturer, or 72 inches o.c., whichever is less.
   1. Fully Recessed Mullions: Provide Mullions fully recessed behind louver blades. Where length of louver exceeds fabrication and handling limitations, fabricate with close-fitting blade splices designed to permit expansion and contraction.
   2. Exterior Corners: Prefabricated corner units with mitered and welded blades and with fully recessed mullions at corners.

G. Provide subsills made of same material as louvers or extended sills for recessed louvers.

H. Join frame members to each other and to fixed louver blades with fillet welds concealed from view unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.6  ALUMINUM FINISHES

A. Finish louvers after assembly.

B. High-Performance Organic Finish: Three-coat fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
   1. Color and Gloss: As selected by Architect from manufacturer's full range.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

C. Form closely fitted joints with exposed connections accurately located and secured.

D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Protect unpainted galvanized- and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.

F. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Section 079200 "Joint Sealants" for sealants applied during louver installation.

3.4 ADJUSTING AND CLEANING

A. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.

B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

C. Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.
END OF SECTION
SECTION 090413 - COMMON SUBMITTAL REQUIREMENTS FOR FINISHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
   a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Refer to Section 01330 for quantity of days allowed for review.
2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
   1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering

1. Number submittals as described below to assist tracking.

2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 090561.13 - MOISTURE VAPOR EMISSION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary
      Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes fluid-applied, resin-based, membrane-forming systems that control the
      moisture-vapor-emission rate of high-moisture, interior concrete to prepare it for floor covering
      installation.

1.3 DEFINITIONS
   A. MVE: Moisture vapor emission.
   B. MVER: Moisture vapor emission rate.

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product.
   B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

1.5 INFORMATIONAL SUBMITTALS
   A. Certifications: Furnish written certification that the manufacturer has verified the compatibility
      between the vapor retarder provided and the flooring product scheduled to be applied, including
      adhesives and floor leveling materials.
   B. Flooring Manufacturer Acceptance of Vapor Retarder Application: Furnish a signed written
      statement obtained from flooring manufacturer, stating that the water vapor emission levels,
      after application of vapor retarders, are acceptable and suitable for their flooring application.

1.6 QUALITY ASSURANCE
   A. Manufacturer Qualifications: Employs factory-trained personnel who are available for
      consultation and Project-site inspection.
   B. Installer Qualifications: An authorized representative who is trained and approved by
      manufacturer.
   C. Provide the following upon request:
      1. Qualification Data: For Installer and manufacturer.
2. Product Test Reports: For each MVE-control system, for tests performed by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency.
3. Preinstallation testing reports.
4. Field quality-control reports.
5. Certification: From manufacturer that product is compatible with lightweight concrete.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in original packages and containers, with seals unbroken, bearing manufacturer's labels indicating directions for storage and mixing with other components.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Comply with MVE-control system manufacturer's written instructions for substrate and ambient temperatures, humidity, ventilation, and other conditions affecting system installation.

1. Store system components in a temperature-controlled environment and protected from weather and at ambient temperature of not less than 65 deg F and not more than 85 deg F at least 48 hours before use.

2. Maintain ambient temperature and relative humidity in installation areas within range recommended in writing by MVE-control system manufacturer, but not less than 65 deg F or more than 85 deg F and not less than 40 or more than 60 percent relative humidity, for 48 hours before installation, during installation, and for 48 hours after installation unless longer period is recommended in writing by manufacturer.

3. Install MVE-control systems where concrete surface temperatures will remain a minimum of 5 deg F higher than the dew point for ambient temperature and relative humidity conditions in installation areas for 48 hours before installation, during installation, and for 48 hours after installation unless longer period is recommended in writing by manufacturer.

1.9 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer and Installer agree to repair or replace the applied concrete vapor retarder, the new floor covering or coating, including materials and labor for applied concrete vapor retarder that fails to remain adhered to the substrate or is affected by moisture or alkalinity within the specified warranty period. Manufacturer's warranty requires manufacturer's inspection and written authorization, prior to removal of existing floor covering and applied concrete vapor retarder.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Flooring products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
B. MVE-Control System Capabilities: Capable of suppressing MVE without failure where installed on concrete that exhibits the following conditions:
   1. MVER: Maximum 25 lb of water/1000 sq. ft. when tested according to ASTM F 1869.
   2. Relative Humidity: Maximum 100 percent when tested according to ASTM F 2170 using in situ probes.

C. Water-Vapor Transmission: Through MVE-control system, maximum 0.10 perm when tested according to ASTM E 96/E 96M.

D. Tensile Bond Strength: For MVE-control system, greater than 200 psi with failure in the concrete according to ASTM D 7234.

E. Product shall be compatible with lightweight concrete.

2.2 MVE-CONTROL SYSTEM

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advanced Moisture Control, Inc.
   2. ARDEX Americas.
   3. Dependable, LLC.
   4. Floor Seal Technology, Inc.
   5. KOSTER American Corporation.
   6. MAPEI Corporation.
   7. Schonox HPS North America

B. MVE-Control System: ASTM F 3010-qualified, fluid-applied, two-component, epoxy-resin, membrane-forming system; formulated for application on concrete substrates to reduce MVER to level required for installation of floor coverings indicated and acceptable to manufacturers of floor covering products indicated, including adhesives.
   1. Substrate Primer: Provide MVE-control system manufacturer's concrete-substrate primer if required for system indicated by substrate conditions.
   2. Cementitious Underlayment Primer: If required for subsequent installation of cementitious underlayment products, provide MVE-control system manufacturer's primer to ensure adhesion of products to MVE-control system.
   3. Thickness: Minimum continuous layer thickness >11mils (0.011 in.)
      a. Include minimum thickness to include calculations for rough, absorptive, or porous concrete surfaces

2.3 ACCESSORIES

A. Patching and Leveling Material: Moisture-, mildew-, and alkali-resistant product recommended in writing by MVE-control system manufacturer and with minimum of 3000-psi compressive strength after 28 days when tested according to ASTM C 109/C 109M.

B. Crack-Filling Material: Resin-based material recommended in writing by MVE-control system manufacturer for sealing concrete substrate crack repair.

C. Cementitious Underlayment: If required to maintain manufacturer's warranty, provide MVE-control system manufacturer's hydraulic cement-based underlayment.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for maximum moisture content, installation tolerances, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
   1. Installation of system indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Preinstallation Testing:
   1. Testing Agency: District will engage a qualified testing agency to perform tests.
   2. Alkalinity Testing: Perform pH testing according to ASTM F 710. Install MVE-control system in areas where pH readings are less than 7.0 Insert value and in areas where pH readings are greater than 8.5.
   3. Moisture Testing: Perform tests so that each test area does not exceed 200 sq. ft. 1000 sq. ft., and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
      a. Anhydrous Calcium Chloride Test: ASTM F 1869. Install MVE-control system in locations where concrete substrate MVER exceeds 3 lb of water/1000 sq. ft. in 24 hours.
      b. Internal Relative Humidity Test: Using in situ probes, ASTM F 2170. Install MVE-control system in locations where concrete substrates exhibit relative humidity level greater than 75 percent.
   4. Tensile-Bond-Strength Testing: For typical locations indicated to receive installation of MVE-control system, install minimum 100 sq. ft. area of MVE-control system to prepared concrete substrate and test according to ASTM D 7234.
      a. Proceed with installation only where tensile bond strength is greater than 200 psi with failure in the concrete.

B. Concrete Substrates: Prepare and clean substrates according to MVE-control system manufacturer's written instructions to ensure adhesion of system to concrete.
   1. Remove coatings and other substances that are incompatible with MVE-control system and that contain soap, wax, oil, or silicone, using mechanical methods recommended in writing by MVE-control system manufacturer. Do not use solvents.
   2. Provide concrete surface profile complying with ICRI 310.2R CSP 3 by shot blasting using apparatus that abrades the concrete surface with shot, contains the dispensed shot within the apparatus, and recirculates the shot by vacuum pickup.
   3. After shot blasting, repair damaged and deteriorated concrete according to MVE-control system manufacturer's written instructions.
   4. Protect substrate voids and joints to prevent resins from flowing into or leaking through them.
   5. Fill surface depressions and irregularities with patching and leveling material.
   6. Fill surface cracks, grooves, control joints, and other nonmoving joints with crack-filling material.
   7. Allow concrete to dry, undisturbed, for period recommended in writing by MVE-control system manufacturer after surface preparation, but not less than 24 hours.

C. Protect walls, floor openings, electrical openings, door frames, and other obstructions during installation.

3.3 INSTALLATION

A. General: Install MVE-control system according to ASTM F 3010 and manufacturer's written instructions to produce a uniform, monolithic surface free of surface deficiencies such as pin holes, fish eyes, and voids.
   1. Install primers as required to comply with manufacturer's written instructions.

B. Do not apply MVE-control system across substrate expansion, isolation, and other moving joints.

C. Apply system, including component coats if any, in thickness recommended in writing by MVE-control system manufacturer for MVER indicated by preinstallation testing.

D. Cure MVE-control system components according to manufacturer's written instructions. Prevent contamination or other damage during installation and curing processes.

E. After curing, examine MVE-control system for surface deficiencies. Repair surface deficiencies according to manufacturer's written instructions.

F. Install cementitious underlayment over cured membrane if required to maintain manufacturer's warranty and in thickness required to maintain the warranty.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: District will engage a qualified testing agency to perform installation inspections.

B. Installation Inspections: Inspect substrate preparation and installation of system components to ensure compliance with manufacturer's written instructions and to ensure that a complete MVE-control system is installed without deficiencies.
   1. Verify that surface preparation meets requirements.
   2. Verify that component coats and complete MVE-control-system film thicknesses comply with manufacturer's written instructions.
   3. Verify that MVE-control-system components and installation areas that evidence deficiencies are repaired according to manufacturer's written instructions.

C. MVE-control system will be considered defective if it does not pass inspections.

3.5 PROTECTION

A. Protect MVE-control system from damage, wear, dirt, dust, and other contaminants before floor covering installation. Use protective methods and materials, including temporary coverings, recommended in writing by MVE-control system manufacturer.

B. Do not allow subsequent preinstallation examination and testing for floor covering installation to damage, puncture, or otherwise compromise the MVE-control system membrane.
END OF SECTION
SECTION 092116.23 - GYPSUM BOARD SHAFT WALL ASSEMBLIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes gypsum board shaft wall assemblies.

1.3 ACTION SUBMITTALS
A. Product Data: For each component of gypsum board shaft wall assembly.
B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

1.4 DELIVERY, STORAGE, AND HANDLING
A. Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and support them on risers on a flat platform to prevent sagging.

1.5 FIELD CONDITIONS
A. Environmental Limitations: Comply with gypsum-shaftliner-board manufacturer's written instructions.
B. Do not install finish panels until installation areas are enclosed and conditioned.
C. Do not install panels that are wet, moisture damaged, or mold damaged.
   1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, and irregular shape.
   2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing agency.
B. STC-Rated Assemblies: Provide materials and construction identical to those of assemblies tested according to ASTM E 90 and classified according to ASTM E 413 by a testing and inspecting agency.

C. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

D. Regional Materials: Products shall be manufactured within 100 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

2.2 GYPSUM BOARD SHAFT WALL ASSEMBLIES

A. Fire-Resistance Rating: As indicated.

B. STC Rating: 51, minimum.

C. Gypsum Shaftliner Board:
   1. Moisture- and Mold-Resistant, Fiberglass-Mat Faced: ASTM C 1658/C 1658M; manufacturer's proprietary fire-resistive liner panels with ASTM D 3273 mold-resistance score of 10 as rated according to ASTM D 3274, 1 inch thick, and with double beveled long edges.
      a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
         1) Georgia-Pacific Building Products; Dens-Glass Shaftliner.
         2) National Gypsum Company Gold Bond eXP Shaftliner.
         3) United States Gypsum Company; Sheetrock Glass-Mat Liner Panel.

D. Non-Load-Bearing Steel Framing, General: Complying with ASTM C 645 requirements for metal unless otherwise indicated and complying with requirements for fire-resistance-rated assembly indicated.

E. studs: Manufacturer's standard profile for repetitive, corner, and end members as follows:
   1. Depth: 6 inches.
   2. Minimum Base-Metal Thickness: As indicated.

F. Runner Tracks: Manufacturer's standard J-profile track with manufacturer's standard long-leg length, but at least 2 inches long and matching studs in depth.
   1. Minimum Base-Metal Thickness: Matching steel studs.

G. Firestop Tracks: Top runner manufactured to allow partition heads to expand and contract with movement of the structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.

H. Elevator-Hoistway-Entrance Struts: Manufacturer's standard J-profile jamb strut with long-leg length of 3 inches, matching studs in depth, and not less than 0.033 inch thick.

I. Finish Panels: Gypsum board as specified in Section 092900 "Gypsum Board."
J. Sound Attenuation Blankets: As specified in Section 098100 "Acoustical Insulation."

2.3 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with shaft wall manufacturer's written instructions.

B. Trim Accessories: Cornerbead, edge trim, and control joints of material and shapes as specified in Section 092900 "Gypsum Board" that comply with gypsum board shaft wall assembly manufacturer's written instructions for application indicated.

C. Steel Drill Screws: ASTM C 1002 unless otherwise indicated.

D. Track Fasteners: Power-driven fasteners of size and material required to withstand loading conditions imposed on shaft wall assemblies without exceeding allowable design stress of track, fasteners, or structural substrates in which anchors are embedded.
   1. Expansion Anchors: Fabricated from corrosion-resistant materials, with allowable load or strength design capacities calculated according to ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing per ASTM E 488/E 488M conducted by a qualified testing agency.
   2. Power-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with allowable load capacities calculated according to ICC-ES AC70, greater than or equal to the design load, as determined by testing per ASTM E 1190 conducted by a qualified testing agency.

E. Reinforcing: Galvanized-steel reinforcing strips with 0.033-inch minimum thickness of base metal (uncoated).

F. Acoustical Sealant: Section 079200 "Joint Sealants."

G. Gypsum Board Cants:
   1. Gypsum Board Panels: As specified in Section 092900 "Gypsum Board," Type X, 1/2- or 5/8-inch panels.
   2. Adhesive: Laminating adhesive as specified in Section 092900 "Gypsum Board."
   3. Non-Load-Bearing Steel Framing: As specified in Section 092216 "Non-Structural Metal Framing."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine panels before installation. Reject panels that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION

A. General: Install gypsum board shaft wall assemblies to comply with requirements of fire-resistance-rated assemblies indicated and manufacturer's written installation instructions.

B. Do not bridge building expansion joints with shaft wall assemblies; frame both sides of expansion joints with furring and other support.

C. Install supplementary framing in gypsum board shaft wall assemblies around openings and as required for blocking, bracing, and support of gravity and pullout loads of fixtures, equipment, services, heavy trim, furnishings, wall-mounted door stops, and similar items that cannot be supported directly by shaft wall assembly framing.
   1. Elevator Hoistway: At elevator hoistway-entrance door frames, provide jamb struts on each side of door frame.
   2. Reinforcing: Provide where items attach directly to shaft wall assembly as indicated on Drawings; accurately position and secure behind at least one layer of face panel.

D. Penetrations: At penetrations in shaft wall, maintain fire-resistance rating of shaft wall assembly by installing supplementary steel framing around perimeter of penetration and fire protection behind boxes containing wiring devices, elevator call buttons and floor indicators, and similar items.

E. Isolate perimeter of gypsum panels from building structure to prevent cracking of panels while maintaining continuity of fire-rated construction.

F. Firestop Tracks: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.

G. Control Joints: Install control joints according to ASTM C840, in specific locations approved by Architect and as follows, while maintaining fire-resistance rating of gypsum board shaft wall assemblies.
   1. Install at changes in backup material.
   2. Framed Openings:
      a. Doors: Install above both jambs unless indicated or directed otherwise.
      b. Glazed Openings: Install above and below both jambs unless indicated or directed otherwise.
   3. Install at other locations indicated on Drawings.

H. Sound-Rated Shaft Wall Assemblies: Seal gypsum board shaft walls with acoustical sealant at perimeter of each assembly where it abuts other work and at joints and penetrations within each assembly.

I. Gypsum Board Cants: At projections into shaft [exceeding 4 inches] [where indicated], install gypsum board cants covering tops of projections.
   1. Slope cant panels at least 75 degrees from horizontal. Set base edge of panels in adhesive and secure top edges to shaft walls at 24 inches o.c. with screws fastened to shaft wall framing.
   2. Where non-load-bearing steel framing is required to support gypsum board cants, install framing at 24 inches o.c. and extend studs from the projection to shaft wall framing.

J. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch from the plane formed by faces of adjacent framing.
3.3 PROTECTION

A. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.

B. Remove and replace panels that are wet, moisture damaged, or mold damaged.
   1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, and irregular shape.
   2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION
SECTION 092216 - NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Non-load-bearing steel framing systems for interior partitions.

B. Related Requirements:
   1. Section 054000 "Cold-Formed Metal Framing" for exterior and interior load-bearing and exterior non-load-bearing wall studs.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, including manufacturer's height limitation tables.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

1.4 QUALITY ASSURANCE

A. Provide the following upon request:
   1. Product Certificates: For each type of code-compliance certification for studs and tracks.
   2. Evaluation Reports: For embossed steel studs and tracks, firestop tracks, post-installed anchors, and power-actuated fasteners, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction
   3. Code-Compliance Certification of Studs and Tracks: Provide documentation that framing members are certified according to the product-certification program of the Certified Steel Stud Association, the Steel Framing Industry Association, or the Steel Stud Manufacturers Association.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: For fire-resistance-rated assemblies that incorporate non-load-bearing steel framing, provide materials and construction identical to those tested in assembly indicated, according to ASTM E 119 by an independent testing agency.
B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated on Drawings, according to ASTM E 90 and classified according to ASTM E 413 by an independent testing agency.

C. Horizontal Deflection: Refer to manufacturer’s standard height limitation tables based on the following deflection criteria:
   1. For wall assemblies without cladding, limited to 1/240 of the wall height based on horizontal loading of 5 lbf/sq. ft..
   2. For wall assemblies with cladding or tiling, limited to 1/360 of the wall height based on horizontal loading of 10 lbf/sq. ft..

2.2 FRAMING SYSTEMS

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Framing Members, General: Comply with ASTM C 754 for conditions indicated.
   1. Steel Sheet Components: Comply with ASTM C 645 requirements for metal unless otherwise indicated.

C. Studs and Tracks: ASTM C 645. Use either steel studs and tracks or embossed steel studs and tracks.
   1. Conventional Steel Studs and Tracks:
      a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
         1) CEMCO; California Expanded Metal Products Co.
         2) ClarkDietrich Building Systems.
         3) Steel Network, Inc. (The).
      b. Minimum Base-Metal Thickness: Sized according to manufacturer’s published height limitation tables based on horizontal deflection performance requirements indicated.
      c. Depth: As indicated on Drawings.
   2. Embossed Steel Studs and Tracks: Roll-formed and embossed with surface deformations to stiffen the framing members so that they are structurally equivalent to conventional ASTM C 645 steel studs and tracks.
      a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
         1) CEMCO; California Expanded Metal Products Co.
         2) ClarkDietrich Building Systems.
         3) Steel Network, Inc. (The).
      b. Minimum Base-Metal Thickness: Sized according to manufacturer’s published height limitation tables based on horizontal deflection performance requirements indicated.
      c. Depth: As indicated on Drawings.
D. Slip-Type Head Joints: Where indicated, provide one of the following:

1. Clip System: Clips designed for use in head-of-wall deflection conditions that provide a positive attachment of studs to tracks while allowing 1-1/2-inch minimum vertical movement.
   a. Products: Subject to compliance with requirements, provide one of the following as provided by steel stud manufacturer:
      1) CEMCO; California Expanded Metal Products Co.; Deflex Clips.
      2) ClarkDietrich Building Systems; FTC3.
      3) Steel Network, Inc. (The); VertiClip SLD Series.

2. Single Long-Leg Track System: ASTM C 645 top track with 2-inch- deep flanges in thickness not less than indicated for studs, installed with studs friction fit into top track and with continuous bridging located within 12 inches of the top of studs to provide lateral bracing.

3. Double-Track System: ASTM C 645 top outer tracks, inside track with 2-inch- deep flanges in thickness not less than indicated for studs and fastened to studs, and outer track sized to friction-fit over inner track.

4. Deflection Track: Steel sheet top track manufactured to prevent cracking of finishes applied to interior partition framing resulting from deflection of structure above; in thickness not less than indicated for studs and in width to accommodate depth of studs.
   a. Products: available products that may be incorporated into the Work include, but are not limited to, the following:
      1) BlazeFrame Industries; Bare Slotted Track (BST/BST 2).
      2) CEMCO; California Expanded Metal Products Co.; CST Slotted Deflection Track or SLP-TRK Slotted Deflection Track.
      3) ClarkDietrich Building Systems; SLP-TRK Slotted Deflection Track.
      4) Steel Network, Inc. (The); VertiClip SLD or VertiTrack VTD.

E. Firestop Tracks: Top track manufactured to allow partition heads to expand and contract with movement of structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. BlazeFrame Industries; Intumescent Framing, Fire Stop System.
   b. CEMCO; California Expanded Metal Products Co.; FAS Track.
   c. ClarkDietrich Building Systems; BlazeFrame.
   d. FireTrak Corp; FireTrak System attached to studs with FireTrak Posi Klip.

F. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.

1. Minimum Base-Metal Thickness: As indicated, but not less than 0.0329 inch to support equipment indicated.

G. Cold-Rolled Channel Bridging: Steel, 0.0538-inch minimum base-metal thickness, with minimum 1/2-inch- wide flanges.

1. Depth: As indicated on Drawings.
2. Clip Angle: Not less than 1-1/2 by 1-1/2 inches, 0.068-inch- thick, galvanized steel.

H. Hat-Shaped, Rigid Furring Channels: ASTM C 645.

1. Minimum Base-Metal Thickness: As indicated, but not less than 0.0329 inch.
2. Depth: As indicated on Drawings.
I. Cold-Rolled Furring Channels: 0.053-inch uncoated-steel thickness, with minimum 1/2-inch-wide flanges.
   1. Depth: As indicated on Drawings.
   2. Furring Brackets: Adjustable, corrugated-edge-type steel sheet with minimum uncoated-steel thickness of 0.0329 inch.
   3. Tie Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, 0.062-inch-diameter wire, or double strand of 0.048-inch-diameter wire.

J. Z-Shaped Furring: With slotted or nonslotted web, face flange of 1-1/4 inches, wall attachment flange of 7/8 inch, minimum uncoated-metal thickness of 0.0179 inch, and depth required to fit insulation thickness indicated.

2.3 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards.
   1. Fasteners for Steel Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

B. Isolation Strip at Exterior Walls: Provide one of the following:
   2. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch thick, in width to suit steel stud size.

C. Isolation Strip at Curtain Wall Mullion: Provide the following or Architect approved equal:
   1. Product: Mull It Over Products; 55 Classic Sound Barrier Mullion Trim Cap

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames, cast-in anchors, and structural framing, for compliance with requirements and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Suspended Assemblies: Coordinate installation of suspension systems with installation of overhead structure to ensure that inserts and other provisions for anchorages to building structure have been installed to receive hangers at spacing required to support the Work and that hangers will develop their full strength.
   1. Furnish concrete inserts and other devices indicated to other trades for installation in advance of time needed for coordination and construction.
3.3 INSTALLATION, GENERAL

A. Installation Standard: ASTM C 754. Install according to Drawings and manufacturer's published height limitation tables.
   1. Gypsum Board Assemblies: Also comply with requirements in ASTM C 840 that apply to framing installation.

B. Install framing and accessories plumb, square, and true to line, with connections securely fastened.

C. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.

D. Install bracing at terminations in assemblies.

E. Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.

3.4 INSTALLING FRAMED ASSEMBLIES

A. Install framing system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.
   1. Single-Layer Application: As required by horizontal deflection performance requirements, but not greater than 24 inches o.c., unless otherwise indicated.
   2. Multilayer Application: As required by horizontal deflection performance requirements, but not greater than 16 inches o.c., unless otherwise indicated.
   3. Tile Backing Panels: As required by horizontal deflection performance requirements, but not greater than 16 inches o.c., unless otherwise indicated.

B. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.

C. Install studs so flanges within framing system point in same direction.

D. Install tracks at floors and overhead supports. Extend framing full height to structural supports or substrates above suspended ceilings except where partitions are indicated to terminate at suspended ceilings. Continue framing around ducts that penetrate partitions above ceiling.
   1. Slip-Type Head Joints: Where framing extends to overhead structural supports, install to produce joints at tops of framing systems that prevent axial loading of finished assemblies.
   2. Door Openings: Screw vertical studs at jambs to jamb anchor clips on door frames; install track section (for cripple studs) at head and secure to jamb studs.
      a. Install two studs at each jamb unless otherwise indicated.
      b. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2-inch clearance from jamb stud to allow for installation of control joint in finished assembly.
      c. Extend jamb studs through suspended ceilings and attach to underside of overhead structure.
   3. Other Framed Openings: Frame openings other than door openings the same as required for door openings unless otherwise indicated. Install framing below sills of openings to match framing required above door heads.
4. Fire-Resistance-Rated Partitions: Install framing to comply with fire-resistance-rated assembly indicated and support closures and to make partitions continuous from floor to underside of solid structure.
   a. Firestop Track: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.

5. Sound-Rated Partitions: Install framing and acoustical joint sealant to comply with sound-rated assembly indicated.
   a. Install isolation strip assembly at end of wall against perimeter wall or curtain wall mullion.

E. Direct Furring:
   1. Attach to concrete with stub nails or powder-driven fasteners spaced 24 inches o.c.

F. Z-Shaped Furring Members:
   1. Erect insulation, specified in Section 072100 "Thermal Insulation," vertically and hold in place with Z-shaped furring members spaced o.c.
   2. Except at exterior corners, securely attach narrow flanges of furring members to wall with concrete stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches o.c.
   3. At exterior corners, attach wide flange of furring members to wall with short flange extending beyond corner; on adjacent wall surface, screw-attach short flange of furring channel to web of attached channel. At interior corners, space second member no more than 12 inches from corner and cut insulation to fit.

G. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch from the plane formed by faces of adjacent framing.

END OF SECTION
SECTION 092400 - CEMENT PLASTERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Exterior vertical plasterwork (stucco).
   2. Exterior horizontal and nonvertical plasterwork (stucco).

B. Related Requirements:
   1. Section [061600 "Sheathing"] [061643 "Gypsum Sheathing"] for exterior wall sheathings and wall sheathing joint-and-penetration treatments.
   2. Section 072100 "Thermal Insulation" for insulation board used as part of an approved NFPA 285 compliant wall assembly.
   3. Section 072726 "Membrane Air Barriers" for sheet membrane water-resistive air barrier used as part of an approved NFPA 285 compliant plaster wall assembly.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Show locations and installation of control and expansion joints, including plans, elevations, sections, details of components, and attachments to other work.

D. Samples for Initial Selection: For each type of factory-prepared finish coat for each color and each texture available. Manufacturer's standard sizes for color and texture samples.

E. Samples for Verification: For factory-prepared finish coat colors and textures selected, 12 by 12 inches, and prepared on rigid backing.

1.4 INFORMATIONAL SUBMITTALS

A. Certification: Manufacturer's certificate of compliance with NFPA 285 for each component.

B. Test Reports: Test reports indicating approval of each product as part of an NFPA 285 compliant assembly.
1.5 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
   1. Include mockup in standalone exterior wall mockup.
   2. Build mockups for each substrate, color, and finish texture indicated for cement plastering, including accessories.
      a. Size: 100 sq. ft. in surface area.
   3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store materials inside under cover, and keep them dry and protected against damage from weather, moisture, direct sunlight, surface contamination, corrosion, construction traffic, and other causes.

1.7 FIELD CONDITIONS

A. Comply with ASTM C 926 requirements.

B. Exterior Plasterwork:
   1. Apply and cure plaster to prevent plaster drying out during curing period. Use procedures required by climatic conditions, including moist curing, providing coverings, and providing barriers to deflect sunlight and wind.
   2. Apply plaster when ambient temperature is greater than 40 deg F.
   3. Protect plaster coats from freezing for not less than 48 hours after set of plaster coat has occurred.

C. Interior Plasterwork: Maintain room temperatures at greater than 40 deg F for at least 48 hours before plaster application, and continuously during and after application.
   1. Avoid conditions that result in plaster drying out during curing period. Distribute heat evenly; prevent concentrated or uneven heat on plaster.
   2. Ventilate building spaces as required to remove water in excess of that required for hydrating plaster in a manner that prevents drafts of air from contacting surfaces during plaster application and until plaster is dry.

D. Factory-Prepared Finishes: Comply with manufacturer's written recommendations for environmental conditions for applying finishes.
PART 2 - PRODUCTS

2.1 FIRE PERFORMANCE REQUIREMENTS

A. Fire Propagation Characteristics: Cement plaster, lath, and associated components shall have passed NFPA 285 testing as part of an approved assembly. Substitution of listed products, if approved by Architect as an equal, shall be with comparable products meeting same fire propagation requirements as a component in a listed assembly tested and approved by Underwriter Laboratories, Inc. or another third party testing agency acceptable to the governing authority. Engineering Judgments prepared by the manufacturer shall be preapproved by the authority having jurisdiction.

B. It is not the intention to preclude the use of other comparable products as approved by the Architect, as long as the product meets the criteria and complies with NFPA 285 as part of an approved assembly. Substitution requests shall include certification and technical data from the manufacturer indicating that the product has been tested and approved in a listed assembly. Components of an approved NFPA 285-compliant air-barrier assembly include the following:

1. Plaster Assembly: Water-resistive-barrier on exterior glass-mat-faced sheathing on metal studs, with extruded or expanded polystyrene insulation drainage board, metal lath and minimum 3/4 inch thick cement plaster, similar or equal to UL EWS0027, EWS0030, or EWS0025. Other manufacturer's may have similar testing available.

C. Fire-Resistance Ratings: Where indicated, provide cement plaster assemblies identical to those of assemblies tested for fire resistance according to ASTM E 119 by a qualified testing agency.

2.2 METAL LATH


1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. CEMCO; California Expanded Metal Products Co.
   b. ClarkDietrich Building Systems.
   c. MarinoWARE.
   d. Phillips Manufacturing Co.

2. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

3. Diamond-Mesh Lath: Flat or self-furring as indicated or to suit conditions, 3.4 lb/sq. yd..

4. Flat-Rib Lath: Rib depth of not more than 1/8 inch, 3.4 lb/sq. yd..

5. 3/8-inch (10-mm) rib lath is often used where its rigidity is necessary for long spans.

B. Paper Backing: FS UU-B-790a, Type I, Grade D, Style 2 vapor-permeable paper.

1. Provide paper-backed lath at exterior locations indicated, unless otherwise indicated.

2.3 ACCESSORIES

A. General: Comply with ASTM C 1063, and coordinate depth of trim and accessories with thicknesses and number of plaster coats required. Accessories shall be noncombustible.
B. Metal Accessories:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. CEMCO; California Expanded Metal Products Co.
   b. ClarkDietrich Building Systems.
   c. MarinoWARE.
   d. Stockton Products.


5. Casing Beads: Fabricated from zinc; square-edged style; with expanded flanges.
   a. Type 1: Stockton Products; Model J-B Modified, J-bead 5 inches tall by 2-7/8 inches wide with 1/4 inch upturned leg. Provide weep holes in horizontal beads.
   b. Type 2: Stockton Products; Model JCB Modified, J-Caulking Bead 5 inches tall by 2-7/8 inches wide with 1 inch upturned leg. Provide weep holes in horizontal beads.

6. Control Joints, Type Control Joint 1: Fabricated from zinc; one-piece-type, folded pair of unperforated screeds in M-shaped configuration; with perforated flanges and removable protective tape on plaster face of control joint.

7. Two-Piece Expansion Joints, Type Expansion Joint 1: Fabricated from zinc; formed to produce slip-joint and M-shaped reveal that is adjustable up to 3/4 inch wide; with perforated flanges.
   a. Basis-of-Design Product: Stockton Products; Model MSX M-Slide Expansion Joint, or Architect approved equal by listed manufacturer.

C. Aluminum Trim:

1. Basis-of-Design Product: Subject to compliance with requirements, provide listed product by Fry Reglet Corp., or comparable product by one of the following:
   a. Flannery, Inc.
   b. Stockton Products

2. Vented Metal Soffit Trim: Extruded aluminum ventilation screed for 3/4-inch ground, prime painted finish.

   a. Basis-of-Design Product: Fry Reglet Corp.; PCS-75-100 2-PC, or Architect approved equal by listed manufacturer.

   a. Basis-of-Design Product: Fry Reglet Corp.; PCS-75-100, or Architect approved equal by listed manufacturer.
2.4 MISCELLANEOUS MATERIALS

A. Water for Mixing and Finishing Plaster: Potable and free of substances capable of affecting plaster set or of damaging plaster, lath, or accessories.

B. Fiber for Base Coat: Alkaline-resistant glass or polypropylene fibers, 1/2 inch long, free of contaminants, manufactured for use in cement plaster.

C. Fasteners for Attaching Metal Lath to Substrates: ASTM C 1063; with 1-1/4 inch washers.


E. Wire: ASTM A 641/A 641M, Class 1 zinc coating, soft temper, not less than 0.0475-inch diameter unless otherwise indicated.

F. Weather-Resistive-Barrier (WRB): Bituminous self-adhering sheet air barrier complying with Section 072726 "Membrane Air Barriers" as part of NFPA 285 compliant assembly.

G. Rigid Insulation: Expanded polystyrene (XPS) complying with Section 072100 "Thermal Insulation" as part of NFPA 285 compliant assembly.

2.5 PLASTER MATERIALS

A. Portland Cement: ASTM C 150/C 150M, Type I.

B. Colorants for Job-Mixed Finish Coats: Colorfast mineral pigments that produce finish plaster color to match Architect's sample.

C. Lime: ASTM C 206, Type S; or ASTM C 207, Type S.

D. Sand Aggregate: ASTM C 897.

E. Pre-mixed Scratch and Brown Coat Base Coatings: Factory-mixed portland-cement mixture formulated as cement plaster base coats. Include manufacturer's recommended primers and anti-cracking fiberglass reinforcing mesh.
   1. Products: Subject to compliance with requirements, provide one of the following tested and approved systems as part of an NFPA 285 compliant assembly:
      a. Dryvit Systems, Inc.; Dryvit TAFS.
      b. Senergy, BASF Wall Systems, Inc.
      c. Sto Corp.; StoPowerwall
   2. Reinforcing Mesh: Manufacturer's alkali-resistant, fiber reinforcing mesh, medium- and high- impact resistant according to ASTM E 695; 4- and 12- oz per sq.yd. as indicated.

F. Acrylic-Based Finish Coatings: Factory-mixed acrylic-emulsion coating systems formulated with colorfast mineral pigments and fine aggregates; for use over cement plaster base coats as part of an NFPA 285 compliant assembly. Include manufacturer's recommended primers and sealing topcoats for acrylic-based finishes.
   1. Products: Subject to compliance with requirements, provide one of the following components tested in NFPA 285 compliant assembly:
a. Dryvit Systems, Inc.; Dryvit TAFS.
b. Senergy, BASF Wall Systems, Inc.; Senerflex.
c. Sto Corp.; StoPowerwall Finish.

2. Texture: As selected by Architect from manufacturer's available options.
3. Colors: Allow for two.
   a. ECP1: Color 1
   b. ECP2: Color 2

2.6 PLASTER MIXES
A. General: Provide premixed system as part of NFPA 285 compliant assembly or site-mixed system as follows.

B. Comply with ASTM C 926 for applications indicated.
   1. Fiber Content: Add fiber to job-mixed base-coat mixes after ingredients have mixed at least two minutes. Comply with fiber manufacturer's written instructions for fiber quantities in mixes, but do not exceed 1 lb of fiber/cu. yd. of cementitious materials.

C. Job-Mixed Base-Coat Mixes for Use over Metal Lath: Scratch and brown coats for three-coat plasterwork as follows:
   1. Portland Cement Mixes:
      a. Scratch Coat: For cementitious material, mix 1 part portland cement and 0 to 3/4 parts lime. Use 2-1/2 to 4 parts aggregate per part of cementitious material.
      b. Brown Coat: For cementitious material, mix 1 part portland cement and 3/4 to 1-1/2 parts lime. Use 3 to 5 parts aggregate per part of cementitious material, but not less than volume of aggregate used in scratch coat.

D. Job-Mixed Finish-Coat Mixes:
   1. Portland Cement Mix: For cementitious materials, mix 1 part portland cement and 3/4 to 1-1/2 parts lime. Use 1-1/2 to 3 parts aggregate per part of cementitious material.

E. Factory-Prepared Mixes: For cement-based base coats and acrylic-based finish coatings, comply with manufacturer's written instructions.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION
A. Protect adjacent work from soiling, spattering, moisture deterioration, and other harmful effects caused by plastering.
B. Prepare smooth, solid substrates for plaster according to ASTM C 926.

C. Install foam insulation board in vertical drainage ribbons of insulation adhesive to continuously coated fluid-applied weather-resistive barrier membrane on exterior sheathing. Allow to cure before proceeding in accordance with adhesive manufacturer’s instructions. Adhesive shall be compatible with fluid-applied air barrier.

D. Install layer of building paper over insulation prior to attaching metal lath.

3.3 INSTALLATION, GENERAL

A. Install complete wall system, including plaster and lath, insulation, weather-resistive-barrier, exterior sheathing over metal studs in accordance with a tested and approved NFPA 285 compliant assembly.

3.4 INSTALLING METAL LATH

A. Metal Lath: Install according to ASTM C 1063 through rigid board insulation and exterior sheathing into metal wall stud framing or blocking without damaging self-sealing properties of the weather-resistive-barrier. Do not back out fasteners.

1. Partition Framing and Vertical Furring over Continuous Insulation: Install flat-diamond-mesh lath over one layer building paper.

2. Flat-Ceiling and Horizontal Framing: Install flat-rib paper-backed lath over Continuous Insulation, unless otherwise indicated.

3.5 INSTALLING ACCESSORIES

A. Install according to ASTM C 1063 and at locations indicated on Drawings.

B. Reinforcement for External (Outside) Corners:

1. Install lath-type, external-corner reinforcement at exterior locations.

C. Control Joints: Locate as approved by Architect for visual effect and as follows:

1. As required to delineate plasterwork into areas (panels) of the following maximum sizes:
   a. Vertical Surfaces: 144 sq. ft.
   b. Horizontal and Other Nonvertical Surfaces: 100 sq. ft.

2. At distances between control joints of not greater than 18 feet o.c.

3. As required to delineate plasterwork into areas (panels) with length-to-width ratios of not greater than 2-1/2:1.

4. Where control joints occur in surface of construction directly behind plaster.

5. Where plasterwork areas change dimensions, to delineate rectangular-shaped areas (panels) and to relieve the stress that occurs at the corner formed by the dimension change.

D. Vented Metal Reveal Trim: Install vented reveal trim as indicated in exterior soffits. Provide concealed spline to maintain joints in alignment and to allow for thermal movement. Provide mitered corners at changes in direction. Locate joints at expansion joints in cement plaster.
3.6 PLASTER APPLICATION

A. General: Comply with ASTM C 926.
   1. Do not deviate more than plus or minus 1/4 inch in 10 feet from a true plane in finished plaster surfaces when measured by a 10-foot straightedge placed on surface.
   2. Finish plaster flush with metal frames and other built-in metal items or accessories that act as a plaster ground unless otherwise indicated. Where casing bead does not terminate plaster at metal frame, cut base coat free from metal frame before plaster sets and groove finish coat at junctures with metal.
   3. Provide plaster surfaces that are ready to receive field-applied finishes indicated.

B. Walls; Mixes for use over metal lath over building paper having 7/8-inch total thickness, as follows:
   1. Scratch Coat: Portland cement mix or pre-packaged mix with embedded mesh reinforcing.
   2. Brown Coat: Portland cement mix or pre-packaged mix.
   4. Plaster Finish Coats: Apply to provide finish to match Architect's sample.

C. Soffits; Mixes for use over paper-backed metal lath having 3/4-inch total thickness, as follows:
   1. Scratch Coat: Portland cement mix or pre-packaged mix with embedded mesh reinforcing.
   2. Brown Coat: Portland cement mix or pre-packaged mix.
   4. Plaster Finish Coats: Apply to provide float finish.

D. Reinforcing Mesh: Embed mesh into plaster base coat in accordance with manufacturer's instructions and as follows:
   1. First Floor and High-Traffic Areas: One layer 4 oz per sq.yd. over one layer 12 oz per sq.yd.
   2. Second Floor and Above: One layer 12 oz per sq.yd.
   3. Soffits: One layer 4 oz per sq.yd.

E. Acrylic-Based Finish Coatings: Apply coating system, including primers, finish coats, and sealing topcoats, according to manufacturer's written instructions.

F. Concealed Exterior Plasterwork: Where plaster application is used as a base for adhered finishes, omit finish coat.

3.7 PLASTER REPAIRS

A. Repair or replace work to eliminate cracks, dents, blisters, buckles, crazing and check cracking, dry outs, efflorescence, sweat outs, and similar defects and where bond to substrate has failed.

3.8 CLEANING AND PROTECTION

A. Remove temporary protection and enclosure of other work after plastering is complete. Promptly remove plaster from door frames, windows, and other surfaces not indicated to be plastered. Repair floors, walls, and other surfaces stained, marred, or otherwise damaged during plastering.
END OF SECTION
SECTION 092900 - GYPSUM BOARD

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Interior gypsum board.
   2. Tile backing panels.
   4. Gypsum board accessories.

B. Related Requirements:
   1. Section 061600 "Sheathing" for gypsum sheathing for exterior walls.
   2. Section 072100 "Thermal Insulation" for thermal batts installed in stud wall cavities
   3. Section 079200 "Joint Sealants" for acoustical sealant.
   4. Section 092116.23 "Gypsum Board Shaft Wall Assemblies" for metal shaft-wall framing, gypsum shaft liners, and other components of shaft-wall assemblies.
   5. Section 092216 "Non-Structural Metal Framing" for non-structural steel framing that supports gypsum board panels.
   6. Section 098100 "Acoustical Insulation" for sound-attenuation blankets installed as part of sound-rated wall and ceiling assemblies.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Samples for Verification: For the following products:
   1. Trim Accessories: Full-size Sample in 12-inch-long length for each trim accessory indicated.

1.4 QUALITY ASSURANCE

A. Mockups: Build mockups of at least 100 sq. ft. in surface area to demonstrate aesthetic effects and to set quality standards for materials and execution.
   1. Build mockups for the following:
      a. Each level of gypsum board finish indicated for use in exposed locations.
   2. Simulate finished lighting conditions for review of mockups.
   3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
1.5 DELIVERY, STORAGE AND HANDLING

A. Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and supported on risers on a flat platform to prevent sagging.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Comply with ASTM C 840 requirements or gypsum board manufacturer's written instructions, whichever are more stringent.

B. Do not install paper-faced gypsum panels until installation areas are enclosed and conditioned.

C. Do not install panels that are wet, moisture damaged, and mold damaged.
   1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
   2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 119 by an independent testing agency.

B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E 90 and classified according to ASTM E 413 by an independent testing agency.

C. Ceiling and wall materials shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.2 GYPSUM BOARD, GENERAL

A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Regional Materials: Products shall be manufactured within 100 miles of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles of Project site.

C. Size: Provide maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.
2.3 INTERIOR GYPSUM BOARD

A. Gypsum Board, Type X: ASTM C 1396/C 1396M.
   1. Basis-of-design Product: Subject to compliance with requirements, provide the following or comparable by Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Gypsum.
      b. CertainTeed Corporation.
      c. Georgia-Pacific Building Products.
      e. United States Gypsum Company; EcoSmart Panels Firecode X (Basis-of-Design).
   2. Thickness: 5/8 inch.

B. Gypsum Ceiling Board: ASTM C 1396/C 1396M.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Gypsum.
      b. CertainTeed Corporation.
      c. Georgia-Pacific Building Products.
      e. United States Gypsum Company.
   2. Thickness: 1/2 inch or 5/8 inch.

C. Impact-Resistant Gypsum Board: ASTM C 1396/C 1396M gypsum board, tested according to ASTM C 1629/C 1629M.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Gypsum.
      b. CertainTeed Corporation.
      c. Georgia-Pacific Building Products.
      e. United States Gypsum Company.
   2. Core: 5/8 inch, Type X.
   3. Surface Abrasion: ASTM C 1629/C 1629M, meets or exceeds requirements.
   4. Indentation: ASTM C 1629/C 1629M, meets or exceeds Level 1 requirements.
   5. Soft-Body Impact: ASTM C 1629/C 1629M, meets or exceeds Level 1 requirements.
   8. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

D. Mold-Resistant Gypsum Board: ASTM C 1396/C 1396M. With moisture- and mold-resistant core and paper surfaces.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Gypsum.
      b. CertainTeed Corporation.
      c. Georgia-Pacific Building Products.
e. United States Gypsum Company.

2. Core: 5/8 inch, Type X.
4. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

2.4 SPECIALTY GYPSUM BOARD

A. Glass-Mat Interior Gypsum Board: ASTM C 1658/C 1658M. With fiberglass mat laminated to both sides. Specifically designed for interior use.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Georgia-Pacific Building Products; DensArmour Plus.
      b. National Gypsum Company; eXP Interior Extreme.
   2. Core: 5/8 inch, Type X.
   4. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

B. Acoustically Enhanced Gypsum Board: ASTM C 1396/C 1396M. Multilayer products constructed of two layers of gypsum boards sandwiching a viscoelastic sound-absorbing polymer core.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Quiet Solution.
      c. Temple-Inland Building Products by Georgia-Pacific.
   2. Core: 5/8 inch, Type X.

2.5 TILE BACKING PANELS

A. Glass-Mat, Water-Resistant Backing Board: ASTM C 1178/C 1178M, with manufacturer’s standard edges.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation.
      b. Georgia-Pacific Building Products.
      c. National Gypsum Company.
   2. Core: 5/8 inch, Type X.
   3. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

B. Cementitious Backer Units: ANSI A118.9 and ASTM C 1288 or ASTM C 1325, with manufacturer’s standard edges.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. C-Cure.
      b. CertainTeed Corporation.
      c. Custom Building Products.
d. James Hardie Building Products, Inc.
e. National Gypsum Company.
f. United States Gypsum Company.

2. Thickness: As indicated.
3. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

2.6 TRIM ACCESSORIES

A. Interior Trim: ASTM C 1047.
   1. Material: Galvanized or aluminum-coated steel sheet, rolled zinc, plastic, or paper-faced galvanized-steel sheet.
   2. Shapes:
      a. Cornerbead.
      b. LC-Bead: J-shaped; exposed long flange receives joint compound.
      c. L-Bead: L-shaped; exposed long flange receives joint compound.
      d. Expansion (control) joint.

B. Aluminum Trim: Extruded accessories of profiles and dimensions indicated.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Fry Reglet Corporation.
      b. Gordon, Inc.
      c. Pittcon Industries.
   2. Aluminum: Alloy and temper with not less than the strength and durability properties of ASTM B 221, Alloy 6063-T5.
   3. Finish: As indicated.
   4. Products: Provide the following in locations indicated on Drawings, or Architect approved equal.
      a. WALL TRIM TYPE 1 – Fry Reglet; DRM-50-75 2 PIECE finish power coat color white.
      b. WALL TRIM TYPE 2 – Fry Reglet; DRM-625-50 finish powder coat color white.
      c. WALL TRIM TYPE 3 – Fry Reglet; DRM-SNAP-IN-625 finish powder coat color white.

2.7 JOINT TREATMENT MATERIALS

A. General: Comply with ASTM C 475/C 475M.

B. Joint Tape:
   1. Interior Gypsum Board: Paper.
   2. Glass-Mat Gypsum Sheathing Board: 10-by-10 glass mesh.
   3. Tile Backing Panels: As recommended by panel manufacturer.

C. Joint Compound for Interior Gypsum Board: For each coat, use formulation that is compatible with other compounds applied on previous or for successive coats.
   1. Prefilling: At open joints, rounded or beveled panel edges, and damaged surface areas, use setting-type taping compound.
2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use drying-type, all-purpose compound.
   a. Use setting-type compound for installing paper-faced metal trim accessories.
3. Fill Coat: For second coat, use setting-type or sandable topping compound.
4. Finish Coat: For third coat, use sandable topping drying-type, all-purpose compound.

D. Joint Compound for Tile Backing Panels:
   1. Glass-Mat, Water-Resistant Backing Panel: As recommended by backing panel manufacturer.
   2. Water-Resistant Gypsum Backing Board: Use setting-type taping compound and setting-type, sandable topping compound.

2.8 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards and manufacturer's written instructions.

B. Steel Drill Screws: ASTM C 1002 unless otherwise indicated.
   1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch thick.
   2. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.

C. Sound-Attenuation Blankets: As specified in Section 098100 "Acoustical Insulation."

D. Thermal Insulation: As specified in Section 072100 "Thermal Insulation."

E. Acoustical Sealant: Refer to Section 079200 "Joint Sealants."

F. Firestop Putty Pads for Electrical Boxes: Listed intumescent moldable firestop putty pads. Coordinate locations with fire-rated partition types.
   1. Available Products: Subject to compliance with requirements, provide one of the following:
      a. Hilti Corporation; CP 617 6" x 7" Putty Pad or CP 617L 7" x 7" Putty Pad.
      b. Kinetics Noise Control; IsoBacker.
      c. Specified Technologies Inc. (STI); SpecSeal Series SSP Putty Pad.

G. Acoustic Putty Pads for Electrical Boxes: Asbestos-free, putty pads composed of polybutene-butyl and inert fillers. Coordinate locations with sound-rated partition types.
   1. Available Products: Subject to compliance with requirements, provide one of the following:
      a. Kinetics Noise Control; IsoBacker.
      b. Specified Technologies Inc. (STI); SpecSeal Series SSP Putty Pad.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and substrates including welded hollow-metal frames and support framing, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLYING AND FINISHING PANELS, GENERAL

A. Comply with ASTM C 840.

B. Install ceiling panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.

C. Install panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch of open space between panels. Do not force into place.

D. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.

E. Form control and expansion joints with space between edges of adjoining gypsum panels.

F. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.
   1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. in area.
   2. Fit gypsum panels around ducts, pipes, and conduits.
   3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch wide joints to install sealant.

G. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments. Provide 1/4- to 1/2-inch- wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.

H. Attachment to Steel Framing: Attach panels so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.
I. STC-Rated Assemblies: Seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant specified in Section 079200 “Joint Sealants.” Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C 919 and with manufacturer's written instructions for locating edge trim and closing off sound-flanking paths around or through assemblies, including sealing partitions above acoustical ceilings. Install sound-isolation strips at end of wall against perimeter wall or curtain wall mullion in accordance with Section 092261 “Non-Structural Metal Framing.”

J. Install sound attenuation blankets before installing gypsum panels unless blankets are readily installed after panels have been installed on one side.

K. Install fire rated putty pads in fire-rated walls and acoustical putty pads in sound-rated walls before installing gypsum panels. Install according to putty pad manufacturer’s instructions.

L. Install thermal insolation before installing gypsum panels unless blankets are readily installed after panels have been installed on one side.

3.3 APPLYING INTERIOR GYPSUM BOARD

A. Install interior gypsum board in the following locations:
   1. Type X: Typical interior surfaces, except as indicated.
   2. Ceiling Type: Ceiling surfaces.
   3. Mold-Resistant Type: Non-tiled areas in wet locations as indicated on Drawings and where gypsum board must be installed prior to building being enclosed and conditioned.
      1. Impact-Resistant Type: Stairway side of metal-stud-framed stairway enclosures.
      5. Acoustically Enhanced Type: Acoustically-rated sound control partitions.
      6. Tile Backer Board: Either glass-mat-faced or cement backer boards.

B. Single-Layer Application:
   1. On ceilings, apply gypsum panels before wall/partition board application to greatest extent possible and at right angles to framing unless otherwise indicated.
   2. On partitions/walls, apply gypsum panels horizontally (perpendicular to framing) unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.
      a. Stagger abutting end joints not less than one framing member in alternate courses of panels.
      b. At stairwells and other high walls, install panels horizontally unless otherwise indicated or required by fire-resistance-rated assembly.
   3. On Z-shaped furring members, apply gypsum panels vertically (parallel to framing) with no end joints. Locate edge joints over furring members.
   4. Fastening Methods: Apply gypsum panels to supports with steel drill screws.

C. Multilayer Application:
   1. On ceilings, apply gypsum board indicated for base layers before applying base layers on walls/partitions; apply face layers in same sequence. Apply base layers at right angles to framing members and offset face-layer joints one framing member, 16 inches minimum, from parallel base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly.
2. On partitions/walls, apply gypsum board indicated for base layers and face layers vertically (parallel to framing) with joints of base layers located over stud or furring member and face-layer joints offset at least one stud or furring member with base-layer joints unless otherwise indicated or required by fire-resistance-rated assembly. Stagger joints on opposite sides of partitions.

3. On Z-shaped furring members, apply base layer vertically (parallel to framing) and face layer either vertically (parallel to framing) or horizontally (perpendicular to framing) with vertical joints offset at least one furring member. Locate edge joints of base layer over furring members.

4. Fastening Methods: Fasten base layers with screws; fasten face layers with adhesive and supplementary fasteners.

3.4 APPLYING TILE BACKING PANELS

A. Glass-Mat, Water-Resistant Backing Panels: Comply with manufacturer's written installation instructions and install at locations indicated to receive tile. Install with 1/4-inch gap where panels abut other construction or penetrations.

B. Cementitious Backer Units: Comply with manufacturer's written installation instructions and install in accordance with ANSI A108.11.

C. Water-Resistant Backing Board: Install where indicated with 1/4-inch gap where panels abut other construction or penetrations.

D. Where tile backing panels abut other types of panels in same plane, shim surfaces to produce a uniform plane across panel surfaces.

3.5 INSTALLING TRIM AND ACCESSORIES

A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.

B. Control Joints: Install control joints according to ASTM C 840, in specific locations approved by Architect for visual effect and as follows.

1. Install at changes in backup material.
2. Framed Openings:
   a. Doors: Install above both jambs unless indicated or directed otherwise.
   b. Glazed Openings: Install above and below both jambs unless indicated or directed otherwise.
3. Install at other locations indicated on Drawings.

C. Interior Trim: Install in the following locations:

1. Cornerbead: Use at outside corners.
2. LC-Bead: Use at exposed panel edges.
3. L-Bead: Use where indicated.
4. U-Bead: Use where indicated.

D. Aluminum Trim: Install in locations indicated on Drawings in accordance with manufacturer's instructions.
E. Firestop Putty Pads: Install at electrical boxes located in fire-rated partitions. Install in accordance with pad manufacturer's instructions.

F. Acoustic Putty Pads: Install at electrical boxes located in acoustic-rated partitions. Install in accordance with pad manufacturer's instructions.

3.6 FINISHING GYPSUM BOARD

A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.

B. Prefill open joints and damaged surface areas.

C. Apply joint tape over gypsum board joints, except for trim products specifically indicated as not intended to receive tape.

D. Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C 840:
   1. Level 1: Ceiling plenum areas, concealed areas, behind built-in cabinets and equipment, and where indicated.
   2. Level 2: Panels that are substrate for tile.
   3. Level 3: Panels that are substrate for heavy grade wall coverings.
   4. Level 4: Typical at panel surfaces that will be exposed to view, unless otherwise indicated, including panels scheduled to receive flat or eggshell paint finish, or light-grade wall coverings.
      a. Primer and its application to surfaces are specified in Section 099123 "Interior Painting."
   5. Level 5: Apply skimcoat and feather out the corners as detailed. Refer to locations indicated on Drawings as follows:
      a. Locations:
         1) At panel surfaces scheduled to receive gloss or semigloss paint finish.
         2) Outer-shell (lobby side) of planetarium enclosure.
         3) Lobby at first, second, and third floor walls and ceilings/soffits.
         4) Other surfaces subject to severe or critical natural or artificial side lighting.
      b. Primer and its application to surfaces are specified in Section 099123 "Interior Painting."

E. Glass-Mat Gypsum Sheathing Board: Finish according to manufacturer's written instructions for use as exposed soffit board.

F. Glass-Mat Faced Panels: Finish according to manufacturer's written instructions.

G. Cementitious Backer Units: Finish according to manufacturer's written instructions.

3.7 PROTECTION

A. Protect adjacent surfaces from drywall compound and promptly remove from floors and other non-drywall surfaces. Repair surfaces stained, marred, or otherwise damaged during drywall application.
B. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.

C. Remove and replace panels that are wet, moisture damaged, and mold damaged.
   1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
   2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION
SECTION 093013 - TILING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Porcelain tile.
   2. Solid surface thresholds.
   3. Waterproof membrane.
   4. Crack isolation membranes.
   5. Metal edge strips.

B. Related Requirements:
   1. Section 079200 "Joint Sealants" for sealing of expansion, contraction, control, and isolation joints in tile surfaces.
   2. Section 092900 "Gypsum Board" for glass-mat, water-resistant backer board.

1.3 DEFINITIONS

A. General: Definitions in the ANSI A108 series of tile installation standards and in ANSI A137.1 apply to Work of this Section unless otherwise specified.


C. Module Size: Actual tile size plus joint width indicated.

D. Face Size: Actual tile size, excluding spacer lugs.

E. Wet Area: The term "wet area" refers to shower rooms and other areas with similar usages. It does not refer to toilet rooms and other similar areas where water on the floor is seldom encountered.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review requirements in ANSI A108.01 for substrates and for preparation by other trades.
1.5 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal and Samples submittal. Ensure compliance with requirements included in Section 090413.

B. Product Data: For each type of product.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Shop Drawings: Show locations of each type of tile and tile pattern. Show widths, details, and locations of expansion, contraction, control, and isolation joints in tile substrates and finished tile surfaces.

E. Samples for Initial Selection: For tile, grout, and accessories involving color selection.

F. Samples for Verification:
   1. Full-size units of each type and composition of tile and for each color and finish required. For ceramic mosaic tile in color blend patterns, provide full sheets of each color blend.
   2. Assembled samples mounted on a rigid panel, with grouted joints, for each type and composition of tile and for each color and finish required. Make samples at least 36 inches square, but not fewer than four tiles. Use grout of type and in color or colors approved for completed Work.
   3. Solid surface thresholds in 6-inch lengths.
   4. Metal edge strips in 6-inch lengths.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match and are from same production runs as products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Tile and Trim Units: Furnish quantity of full-size units equal to 3 percent of amount installed for each type, composition, color, pattern, and size indicated.
   2. Grout: Furnish quantity of grout equal to 3 percent of amount installed for each type, composition, and color indicated.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installer is a five-star member of the National Tile Contractors Association or a Trowel of Excellence member of the Tile Contractors’ Association of America.

B. Provide the following upon request:
   1. Qualification Data: For Installer.
   2. Product Certificates: For each type of product.

C. Mockups: Build in-place visual mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Build mockup of each type of floor tile installation.
   2. Build mockup of each type of wall tile installation with base.
3. Build mockup of landscape rock installation; approximately 48 sq. ft. to demonstrate aesthetic effect.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use. Comply with requirements in ANSI A137.1 for labeling tile packages.

B. Store tile and cementitious materials on elevated platforms, under cover, and in a dry location.

C. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.

D. Store liquid materials in unopened containers and protected from freezing.

1.9 FIELD CONDITIONS

A. Environmental Limitations: Do not install tile until construction in spaces is complete and ambient temperature and humidity conditions are maintained at the levels indicated in referenced standards and manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations for Tile: Obtain tile of each type and color or finish from single source or producer.
   1. Obtain tile of each type and color or finish from same production run and of consistent quality in appearance and physical properties for each contiguous area.

B. Source Limitations for Setting and Grouting Materials: Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from single manufacturer and each aggregate from single source or producer.
   1. Obtain setting and grouting materials, except for unmodified Portland cement and aggregate, from single manufacturer.
   2. Obtain waterproof membrane and crack isolation membrane, except for sheet products, from manufacturer of setting and grouting materials.

C. Source Limitations for Other Products: Obtain each of the following products specified in this Section from a single manufacturer:
   1. Solid surface thresholds.
   2. Waterproof membrane.
   3. Crack isolation membrane.
   4. Metal edge strips.

D. For full system warranty, provide the following products from single manufacturer as indicated. This does not preclude the use of other products or other manufacturer's offering the same warranted system.
1. Tile setting mortar.
2. Grout
4. Uncoupling membrane.
5. Crack isolation membrane.

2.2 PRODUCTS, GENERAL

A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.
   1. Provide tile complying with Standard grade requirements unless otherwise indicated.

B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI A108.02, ANSI standards referenced in other Part 2 articles, ANSI standards referenced by TCNA installation methods specified in tile installation schedules, and other requirements specified.

C. Dynamic Coefficient of Friction: Provide tile installed on walkway surfaces with dynamic coefficient of friction indicated as determined by testing identical products per ANSI A137.1 DCOF AcuTest procedure.
   1. Dynamic Coefficient of Friction: Not less than 0.42.

D. Factory Blending: For tile exhibiting color variations within ranges, blend tile in factory and package so tile units taken from one package show same range in colors as those taken from other packages and match approved Samples.

E. Mounting: For factory-mounted tile, provide back- or edge-mounted tile assemblies as standard with manufacturer unless otherwise indicated.
   1. Where tile is indicated for installation in wet areas, do not use back- or edge-mounted tile assemblies unless tile manufacturer specifies in writing that this type of mounting is suitable for installation indicated and has a record of successful in-service performance.

2.3 TILE PRODUCTS

A. General: Refer to Drawings for tile type, manufacturer, and size.

B. Landscape Rocks: Refer to Drawings; Vary size between 2-1/2-inch and 5-inch diameter.

2.4 THRESHOLDS

A. General: Fabricate to sizes and profiles indicated or required to provide transition between adjacent floor finishes.
   1. Bevel edges at 1:2 slope, with lower edge of bevel aligned with or up to 1/16 inch above adjacent floor surface. Finish bevel to match top surface of threshold. Limit height of threshold to 1/2 inch or less above adjacent floor surface.

B. Solid-Surface Material Thresholds: Homogeneous solid thresholds of filled plastic resin complying with ANSI SS1.
   1. Type: Standard Type.
   2. Colors and Patterns: As selected by Architect from manufacturer's full range.
2.5 TILE BACKING PANELS

A. Specified in Section 092900 "Gypsum Board."

2.6 WATERPROOF MEMBRANE

A. General: Manufacturer's standard product, selected from the following, that complies with ANSI A118.10 and is recommended by the manufacturer for the application indicated. Include reinforcement and accessories recommended by manufacturer.

B. Manufacturer's: Subject to compliance with requirements, provide products from one of the following manufacturer's, or provide listed product for full system warranty:
   1. Custom Building Products
   2. Laticrete International, Inc.
   3. MAPEI Corporation;

C. Fluid-Applied Membrane: Liquid-latex rubber or elastomeric polymer.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following for full-system warranty, or Architect approved equal by listed manufacturer:

2.7 CRACK ISOLATION MEMBRANE

A. General: Manufacturer's standard product that complies with ANSI A118.12 for high performance and is recommended by the manufacturer for the application indicated. Include reinforcement and accessories recommended by manufacturer.

B. Manufacturer's: Subject to compliance with requirements, provide products from one of the following manufacturer's, or provide listed product for full system warranty:
   1. Custom Building Products
   2. Laticrete International, Inc.
   3. MAPEI Corporation;

   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following for full-system warranty, or Architect approved equal by listed manufacturer:
      a. Product: Laticrete International, Inc.; Fracture Ban

2.8 UNCOUPLING MEMBRANE

A. General: Manufacturer's standard product that complies with ANSI A118.12 for high performance and is recommended by the manufacturer for the application indicated. Include reinforcement and accessories recommended by manufacturer.

B. Manufacturer's: Subject to compliance with requirements, provide products from one of the following manufacturer's, or provide listed product for full system warranty:
   1. Custom Building Products
   2. Laticrete International, Inc.
3. Schluter Systems, LLP.

   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following for full-system warranty, or Architect approved equal by listed manufacturer:
      a. Laticrete International, Inc.; Strata Mat

2.9 SETTING MATERIALS

   1. Cleavage Membrane: Asphalt felt, ASTM D 226/D 226M, Type I (No. 15); or polyethylene sheeting, ASTM D 4397, 4.0 mils thick.

B. Manufacturer's: Subject to compliance with requirements, provide products from one of the following manufacturer's, or provide listed product for full system warranty:
   1. ARDEX GmbH.
   2. Custom Building Products.
   3. Laticrete International, Inc.
   4. MAPEI Corporation.

C. Setting Mortar and Bond Coat: Polymer-modified mortar adhesive (Thinset Bond Coat); ANSI A118.4.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following for full-system warranty, or Architect approved equal by listed manufacturer:
      a. Floor Product: Laticrete International Inc.; Laticrete 254 Platinum, or 254R for rapid-setting.

2.10 GROUT MATERIALS

A. Manufacturer's: Subject to compliance with requirements, provide products from one of the following manufacturer's, or provide listed product for full system warranty:
   1. ARDEX GmbH.
   2. Custom Building Products.
   3. Laticrete International, Inc.
   4. MAPEI Corporation.

B. High-Performance Tile Grout: ANSI A118.7.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following for full-system warranty, or Architect approved equal by listed manufacturer:
      a. Laticrete International Inc.; Permacolor grout.
   2. Reference Finish Schedule for grout color and joint thickness.

C. Water-Cleanable Epoxy Grout: ANSI A118.3.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following for full-system warranty, or Architect approved equal by listed manufacturer:
2. Reference Finish Schedule for grout color and joint thickness.

2.11 MISCELLANEOUS MATERIALS

A. Trowelable Underlayments and Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.

B. Vapor- Retarder Membrane: Polyethylene sheeting, ASTM D 4397, 4.0 mils thick, tape seams.

C. Mesh Tape: 2-inch wide self-adhesive fiberglass mesh tape as instructed by backer manufacturer.

D. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.

2.12 METAL EDGE STRIPS

A. Metal Edge Strips: Tile edge protection and transitions strips of width shown, of height required to protect exposed edges of tile, and maximum available lengths to minimize running joints; satin anodized aluminum.

1. Basis of Design Manufacturers: Subject to compliance with requirements, provide the following basis-of-design shapes as manufactured by Schluter Systems, LP, as required for the Project, or comparable by one of the following:
   b. Progress Profiles.

2. Basis-of-Design Products: As occurs. Sizes as indicated on Drawings.
   a. Tile to Concrete Floor: Schluter Reno Ramp
   b. Tile to Flush Height Carpet: Schluter Schiene
   c. Tile to Thin Carpet: Schluter Reno-TK
   d. Tile to Resilient Flooring: Schluter Reno-U
   e. Tile wainscot top and exposed Edges: Schluter Rondec-DB
   f. Other conditions as required or indicated as directed by Architect.

2.13 ELASTOMERIC SEALANTS

A. General: Provide sealants, primers, backer rods, and other sealant accessories that comply with the following requirements and with the applicable requirements in Section 07 9200 "Joint Sealants."

1. Sealants shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Use primers, backer rods, and sealant accessories recommended by sealant manufacturer.

B. Colors: Provide colors of exposed sealants to match colors of grout in tile adjoining sealed joints unless otherwise indicated.

2.14 MIXING MORTARS AND GROUT

A. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.
B. Add materials, water, and additives in accurate proportions.

C. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify that substrates for setting tile are firm; dry; clean; free of coatings that are incompatible with tile-setting materials, including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.

2. Verify that concrete substrates for tile floors installed with adhesives bonded mortar bed thinset mortar comply with surface finish requirements in ANSI A108.01 for installations indicated.
   a. Verify that surfaces that received a steel trowel finish have been mechanically scarified.
   b. Verify that protrusions, bumps, and ridges have been removed by sanding or grinding.

3. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind tile has been completed.

4. Verify that joints and cracks in tile substrates are coordinated with tile joint locations; if not coordinated, adjust joint locations in consultation with Architect.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Refer to TCNA EJ171 for treatment of tile setting at movement joints. Do not bridge movement joints.

B. Cracks: Provide crack isolation sheet membrane or fluid-applied waterproofing compound to existing cracks with width equal to 3 times width of the tile and then place a 6 inch strip of glass fiber mesh reinforcement, or comparable product as recommended by tile setting material manufacturer, centered on the crack and firmly embedded in the waterproofing compound in accordance with TCNA F125 - Partial. If deemed necessary to install full coverage crack isolation membrane, install according to TCNA F125- Full.

C. Blending: For tile exhibiting color variations, verify that tile has been factory blended and packaged so tile units taken from one package show same range of colors as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.

D. Lightweight Concrete Slabs: Verify compatibility of tile products with use on lightweight concrete. Prepare slab as instructed by setting material and waterproofing material manufacturers.
E. Install tile backer boards on metal studs and prepare for tile installation according to Section 092900 "Gypsum Board."

3.3 CERAMIC TILE INSTALLATION

A. Comply with TCNA's "Handbook for Ceramic, Glass, and Stone Tile Installation" for TCNA installation methods specified in tile installation schedules. Comply with parts of the ANSI A108 series "Specifications for Installation of Ceramic Tile" that are referenced in TCNA installation methods, specified in tile installation schedules, and apply to types of setting and grouting materials used.

1. For the following installations, follow procedures in the ANSI A108 series of tile installation standards for providing 95 percent mortar coverage:
   a. Tile floors in wet areas.
   b. Tile floors consisting of tiles 8 by 8 inches or larger.
   c. Tile floors consisting of rib-backed tiles.

B. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.

C. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.

D. Provide manufacturer's standard trim shapes where necessary to eliminate exposed tile edges.

E. Where accent tile differs in thickness from field tile, vary setting-bed thickness so that tiles are flush.

F. Jointing Pattern: Lay tile in grid pattern unless otherwise indicated. Lay out tile work and center tile fields in both directions in each space or on each wall area. Lay out tile work to minimize the use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.

1. For tile mounted in sheets, make joints between tile sheets same width as joints within tile sheets so joints between sheets are not apparent in finished work.
2. Where adjoining tiles on floor, base, walls, or trim are specified or indicated to be same size, align joints.
3. Where tiles are specified or indicated to be whole integer multiples of adjoining tiles on floor, base, walls, or trim, align joints unless otherwise indicated.

G. Joint Widths: Unless otherwise indicated, install tile with the following joint widths:

1. Porcelain Tile: 1/16 inch.

H. Lay out tile wainscots to dimensions indicated or to next full tile beyond dimensions indicated.

I. Expansion Joints: Provide expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated. Form joints during installation of setting materials, mortar beds, and tile. Do not saw-cut joints after installing tile.

1. Where joints occur in concrete substrates, locate joints in tile surfaces directly above them.
2. Apply sealant and back-up to joints.
3. Apply sealant to junction of tile and dissimilar materials and junction of dissimilar planes.

J. Solid Surface Thresholds: Install thresholds in same type of setting bed as adjacent floor unless otherwise indicated.
   1. Do not extend cleavage membrane, waterproofing, or crack isolation membrane under thresholds set in modified dry-set mortar. Fill joints between such thresholds and adjoining tile set on waterproofing or crack isolation membrane with elastomeric sealant.

K. Metal Edge Strips: Install at exposed edges, and where edge of tile flooring meets carpet or resilient flooring that finishes flush with or below top of tile and no threshold is indicated.

3.4 WATERPROOFING INSTALLATION

A. Install waterproofing to comply with ANSI A108.13 and manufacturer's written instructions to produce waterproof membrane of uniform thickness that is bonded securely to substrate.

B. Allow waterproofing to cure and verify by testing that it is watertight before installing tile or setting materials over it.

3.5 CRACK ISOLATION MEMBRANE INSTALLATION

A. Install crack isolation membrane to comply with ANSI A108.17 and manufacturer's written instructions to produce membrane of uniform thickness that is bonded securely to substrate.

B. Allow crack isolation membrane to cure before installing tile or setting materials over it.

C. When allowed by waterproof membrane manufacturer, crack isolation membrane may be omitted where fluid-applied waterproofing is indicated.

3.6 UNCOUPLING MEMBRANE INSTALLATION

A. Install uncoupling membrane to comply with manufacturer's written instructions using mortar bond coat on properly prepared waterproof membrane. Provide typical under porcelain and large format tile.

3.7 INSTALLATION - FLOORS - THIN-SET METHODS

A. General: Refer to TCNA design methods and tile installation Schedule at the end of this Section to suit condition. Not all conditions may be listed, and in some cases methods have been modified and combined to meet specific project conditions.

3.8 INSTALLATION - FLOORS - MORTAR BED METHODS

A. General: Refer to TCNA design methods and tile installation Schedule at the end of this Section to suit condition. Not all conditions may be listed, and in some cases methods have been modified and combined to meet specific project conditions.
3.9 INSTALLATION - WALL TILE
   A. General: Refer to TCNA design methods and tile installation Schedule at the end of this Section to suit condition. Not all conditions may be listed, and in some cases methods have been modified and combined to meet specific project conditions.
   B. Over cementitious backer board on vapor retarder membrane on metal studs, install with modified non-sagging cement mortar adhesive in accordance with TCNA Method W244 with high-performance grout.
   C. Over coated glass mat backer board on metal studs, install with modified non-sagging cement mortar adhesive in accordance with TCNA Method W248 with high-performance grout.

3.10 ADJUSTING AND CLEANING
   A. Remove and replace tile that is damaged or that does not match adjoining tile. Provide new matching units, installed as specified and in a manner to eliminate evidence of replacement.
   B. Cleaning: On completion of placement and grouting, clean all ceramic tile surfaces so they are free of foreign matter.
      1. Remove grout residue from tile as soon as possible.
      2. Clean grout smears and haze from tile according to tile and grout manufacturer’s written instructions but no sooner than 10 days after installation. Use only cleaners recommended by tile and grout manufacturers and only after determining that cleaners are safe to use by testing on samples of tile and other surfaces to be cleaned. Protect metal surfaces and plumbing fixtures from effects of cleaning. Flush surfaces with clean water before and after cleaning.

3.11 PROTECTION
   A. Protect installed tile work with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear. If recommended by tile manufacturer, apply coat of neutral protective cleaner to completed tile walls and floors.
   B. Prohibit foot and wheel traffic from tiled floors for at least seven days after grouting is completed.
   C. Before final inspection, remove protective coverings and rinse neutral protective cleaner from tile surfaces.

3.12 INTERIOR CERAMIC TILE INSTALLATION SCHEDULE
   A. General: Utilize the following as applicable to conditions indicated on Drawings.
   B. Interior Floor Installations, Concrete Subfloor: Porcelain Tile
      1. Tile Installation: TCNA F111 (Modified) and ANSI A108.1C; cement mortar bed on uncoupling membrane, on- or above- grade.
         a. Setting: Tile set with dry-set bond coat on uncoupling membrane set with dry-set bond coat on unreinforced mortar bed over cleavage membrane, with total thickness to allow flush set tile in recessed concrete slab as indicated.
1) **Bond Coat:** Thinset mortar compatible with uncoupling membrane, either modified or unmodified as instructed by uncoupling membrane manufacturer.

b. Grout: **Provide high-performance unsanded grout at porcelain tile.**

2. **Tile Installation:** TCNA F122; thinset mortar on uncoupling membrane on waterproof membrane, on- or above-grade.

a. **Setting:** Tile thinset with bond coat on uncoupling membrane set with bond coat on waterproof membrane.

   1) **Bond Coat:** Thinset mortar compatible with uncoupling membrane, either modified or unmodified as instructed by uncoupling membrane manufacturer.

b. Grout: **Provide high-performance unsanded grout at porcelain tile.**

   1) Provide high-performance unsanded grout at porcelain tile.

   2) Provide water-cleanable epoxy grout on chemical-resistant floors.

3. **Tile Installation:** TCNA F128; thinset mortar on uncoupling membrane on-grade.

a. **Setting:** Tile thinset with bond coat on uncoupling membrane.

   1) **Bond Coat:** Thinset mortar compatible with uncoupling membrane, either modified or unmodified as instructed by uncoupling membrane manufacturer.

b. Grout: **Provide high-performance unsanded grout at porcelain tile.**

   1) Provide high-performance unsanded grout at porcelain tile.

   2) Provide water-cleanable epoxy grout on restroom floors.

C. **Interior Floor Installations, Concrete Subfloor: Landscape Rocks**

1. Use portland-cement setting mortar over cleavage membrane. Thickness of mortar may vary according to effect and ability to bond rocks to substrate.

D. **Interior Wall Installations, Metal Studs or Furring: Porcelain Tile**

1. Using one of the following methods:

   a. **Porcelain Tile Installation:** TCNA W244C or TCNA W244F; thinset mortar on cementitious backer units over vapor-retarder membrane.

      1) **Tile Type:** Wall tile as indicated.

      2) **Thinset Mortar:** Modified dry-set mortar bond coat.

      3) **Grout:** High-performance grout.

   b. **Porcelain Tile Installation:** TCNA W248; thinset mortar on glass-mat, water-resistant gypsum backer board.

      1) **Tile Type:** Wall tile as indicated.

      2) **Thinset Mortar:** Modified dry-set mortar bond coat.

   c. **Grout:**

      1) Provide high-performance unsanded grout at porcelain tile.

      2) Provide water-cleanable epoxy grout on walls behind toilets.

2. For tile walls with waterproofing, use fluid-applied waterproofing and allow to cure before setting tile with mortar bond coat.
END OF SECTION
SECTION 095113 - SUSPENDED ACOUSTICAL CEILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary
   Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes:
   1. Suspended acoustical panels.
   2. Suspended acoustical clouds.
   3. Suspension systems for interior ceilings.

B. Related Requirements:
   1. Section 095423 “Suspended Metal Ceilings” for suspended metal ceiling baffles.

C. Products furnished, but not installed under this Section, include anchors, clips, and other ceiling
   attachment devices to be cast in concrete.

1.3 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance
   Form may be submitted in lieu of required Product Data submittal and Samples submittal.
   Ensure compliance with requirements included in Section 090413.

B. Product Data: For each type of product.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Samples for Verification: For each component indicated and for each exposed finish required,
   prepared on Samples of sizes indicated below:
   1. Acoustical Panels: Set of 6-inch- square Samples of each type, color, pattern, and
      texture.
   2. Exposed Suspension-System Members, Moldings, and Trim: Set of 6-inch- long
      Samples of each type, finish, and color.

1.4 INFORMATIONAL SUBMITTALS

A. Evaluation Reports: For each acoustical panel ceiling suspension system and anchor and
   fastener type, from ICC-ES.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are
   shown and coordinated with each other, using input from installers of the items involved:
   1. Ceiling suspension-system members.
   2. Structural members to which suspension systems will be attached.
3. Method of attaching hangers to building structure.
   a. Furnish layouts for cast-in-place anchors, clips, and other ceiling attachment
device whose installation is specified in other Sections.

4. Carrying channels or other supplemental support for hanger-wire attachment where
   conditions do not permit installation of hanger wires at required spacing.

5. Size and location of initial access modules for acoustical panels.

6. Items penetrating finished ceiling and ceiling-mounted items including the following:
   a. Lighting fixtures.
   b. Diffusers.
   c. Grilles.
   d. Speakers.
   e. Sprinklers.
   f. Access panels.
   g. Perimeter moldings.

7. Show operation of hinged and sliding components covered by or adjacent to acoustical
   panels.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For finishes to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are
   packaged with protective covering for storage and identified with labels describing contents.
   1. Acoustical Ceiling Units: Full-size panels equal to 2 percent of quantity installed.

1.7 QUALITY ASSURANCE

A. Provide the following upon request:
   1. Qualification Data: For structural engineer and field testing agency.
   2. Product Test Reports: For each acoustical panel ceiling, for tests performed by
    manufacturer and witnessed by a qualified testing agency or by a qualified testing
    agency.
   3. Field quality-control reports.

B. Mockups: Build in-place mockups to verify selections made under Sample submittals, to
   demonstrate aesthetic effects, and to set quality standards for materials and execution.
   1. Build mockup of typical ceiling area as shown on Drawings, not less than 100 sq. ft..
   2. Approval of mockups does not constitute approval of deviations from the Contract
    Documents contained in mockups unless Architect specifically approves such deviations
    in writing.
   3. Subject to compliance with requirements, approved mockups may become part of the
    completed Work if undisturbed at time of Substantial Completion.
1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver acoustical panels, suspension-system components, and accessories to Project site and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

B. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.

1.9 FIELD CONDITIONS

A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

1. Pressurized Plenums: Operate ventilation system for not less than 48 hours before beginning acoustical panel ceiling installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain each type of acoustical ceiling panel and supporting suspension system from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Suspended ceiling installation has been designed to withstand the effects of earthquake motions determined according to ASCE/SEI 7 as amended by 2016 CBC Section 1616.10.18 and Section 1616A.1.21.

B. Recycled Content of Metal Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

C. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: Class A according to ASTM E 1264.
2. Smoke-Developed Index: 50 or less.

2.3 SUSPENDED ACOUSTICAL PANELS AND CLOUDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Armstrong World Industries, Inc.
2. CertainTeed Corporation.
3. Chicago Metallic Corporation.
B. Acoustical Panel Standard: Provide manufacturer's standard panels according to ASTM E 1264 and designated by type, form, pattern, acoustical rating, and light reflectance unless otherwise indicated.

C. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

2.4 METAL SUSPENSION SYSTEM

A. Metal Suspension-System Standard: Provide ceiling panel manufacturer's standard, direct-hung, metal suspension system and accessories according to ASTM C 635/C 635M and designated by type, structural classification, and finish indicated. Refer to A9.4.10 for specified system.

B. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

C. Narrow-Face, Capped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet; prepainted, electrotyically zinc coated, or hot-dip galvanized, G30 coating designation; with prefinished 9/16-inch wide metal caps on flanges as indicated.
   1. Structural Classification: Heavy-duty system.

D. Cloud Suspension: Provide manufacturer's standard deck hanging kit, including grippers, hangers, aircraft cable, panel inserts, and fasteners for groups and individual panels to suit condition.

E. Attachment Devices: Provide as indicated in accordance with ASTM C 635. Refer to Drawings for specific requirements and spacing.
   1. Anchors: Anchors of type and material indicated.
      a. Product: Refer to Drawings.
         1) Corrosion Protection: Carbon-steel components zinc plated according to ASTM B 633, Class SC 1 (mild) service condition.
   2. Power-Actuated Fasteners: Fastener system as indicated.

F. Wire Hangers, Braces, and Ties: Provide wires as follows:
   2. Size: Wire diameter sufficient for its stress at three times hanger design load (ASTM C 635/C 635M, Table 1, "Direct Hung") will be less than yield stress of wire, but not less than 0.106-inch diameter wire.
      3. Size:
         a. Hanger Wire Size: 0.106 inch (No. 12-gauge) diameter wire.
         b. Seismic Bracing Wire Size: 0.106 inch (No. 12-gauge) diameter wire.

G. Hanger Rods: Mild steel, zinc coated or protected with rust-inhibitive paint.

H. Flat Hangers: Mild steel, zinc coated or protected with rust-inhibitive paint.

I. Angle Hangers: Angles with legs not less than 7/8 inch wide; formed with 0.04-inch- thick, galvanized-steel sheet complying with ASTM A 653/A 653M, G90 coating designation; with bolted connections and 5/16-inch- diameter bolts.
J. Hold-Down Clips: Manufacturer’s standard hold-down clip spaced as standard with manufacturer. Provide on ceilings within 20’-0” feet of exterior openings.

K. Seismic Clips: Manufacturer’s standard seismic clips designed to secure acoustical panels in place during a seismic event. Per ESR-1222, provide ACM7 and MAC2 clips.
   1. Location and Spacing: As recommended by manufacturer. Refer to Drawings.

L. Seismic Stabilizer Bars: Manufacturer’s standard perimeter stabilizers designed to accommodate seismic forces.
   1. Location and Spacing: As recommended by manufacturer. Refer to Drawings.

M. Seismic Struts: Manufacturer’s standard compression struts designed to accommodate seismic forces.
   1. Location and Spacing: As recommended by manufacturer. Refer to Drawings.

2.5 METAL EDGE MOLDINGS AND TRIM

A. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer’s standard moldings for edges and penetrations that comply with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension-system runners.
   1. Edge moldings shall fit acoustical panel edge details and suspension systems indicated and match width and configuration of exposed runners unless otherwise indicated.
      a. Provide manufacturer’s seismic perimeter clips used with standard nominal 7/8-inch wall angles, with current ICC Evaluation Service Report (ESR) acceptable to authority having jurisdiction.
   2. For lay-in panels with reveal edge details, provide stepped edge molding that forms reveal of same depth and width as that formed between edge of panel and flange at exposed suspension member.
   3. For circular penetrations of ceiling, provide edge moldings fabricated to diameter required to fit penetration exactly.

B. Edge Moldings and Trim: Provide exposed members as indicated or required to comply with seismic requirements of authorities having jurisdiction, to conceal edges of penetrations through ceiling, to conceal ends of pans and carriers, for fixture trim and adapters, for fasciae at changes in ceiling height, and for other conditions; of metal and finish matching linear metal pans or extruded plastic unless otherwise indicated.

2.6 ACOUSTICAL SEALANT

A. Acoustical Sealant: As specified in Section 079200 “Joint Sealants.”
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, including structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical panel ceilings.

B. Examine acoustical panels before installation. Reject acoustical panels that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders unless otherwise indicated, and comply with layout shown on reflected ceiling plans.

B. Layout openings for penetrations centered on the penetrating items.

3.3 INSTALLATION

A. Install acoustical panel ceilings according to ASTM C 636/C 636M, seismic design requirements, and manufacturer’s written instructions.

1. Seismic Design Requirements: Install in accordance with the following:
   a. ASTM E 580/E 580M for Seismic Design Categories D, E, and F.
   b. ASTM E 580/E580M Section 5 as amended by 2016 CBC Section 1616.10.16 and Section 1616A.1.21.

B. Suspend ceiling hangers from building's structural members and as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.

2. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.

   a. When required, do not splay hangers steeper than 1:6 as described in DSA IR 25.2.

3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension-system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.

4. Secure wire hangers to ceiling-suspension members and to supports above with a minimum of three tight turns. Connect hangers directly to structure or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
5. Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both the structure to which hangers are attached and the type of hanger involved. Install hangers in a manner that will not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.

6. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.

7. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.

8. Do not attach hangers to steel deck tabs.

9. Do not attach hangers to steel roof deck. Attach hangers to structural members.

10. Space hangers not more than 48 inches o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches from ends of each member.

11. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards.

C. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.

D. Install clouds in accordance with manufacturer's instructions.

E. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.

1. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.

2. Screw attach moldings to substrate at intervals not more than 16 inches o.c. and not more than 3 inches from ends. Miter corners accurately and connect securely.

3. Do not use exposed fasteners, including pop rivets, on moldings and trim.

F. Install suspension-system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

G. Install acoustical panels with undamaged edges and fit accurately into suspension-system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide precise fit.

1. Arrange directionally patterned acoustical panels as follows:
   a. As indicated on reflected ceiling plans.
   b. Install panels with pattern running in one direction parallel to [long] [short] axis of space.
   c. Install panels in a basket-weave pattern.

2. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension-system runners and moldings.

3. For reveal-edged panels on suspension-system runners, install panels with bottom of reveal in firm contact with top surface of runner flanges.

4. For reveal-edged panels on suspension-system members with box-shaped flanges, install panels with reveal surfaces in firm contact with suspension-system surfaces and panel faces flush with bottom face of runners.

5. Paint cut edges of panel remaining exposed after installation; match color of exposed panel surfaces using coating recommended in writing for this purpose by acoustical panel manufacturer.
6. Install seismic clips in areas indicated; space according to panel manufacturer's written instructions unless otherwise indicated.
7. Install clean-room gasket system in areas indicated, sealing each panel and fixture as recommended by panel manufacturer's written instructions.
8. Protect lighting fixtures and air ducts according to requirements indicated for fire-resistance-rated assembly.

3.4 ERECTION TOLERANCES

A. Suspended Ceilings: Install main and cross runners level to a tolerance of 1/8 inch in 12 feet, non-cumulative.

B. Moldings and Trim: Install moldings and trim to substrate and level with ceiling suspension system to a tolerance of 1/8 inch in 12 feet, non-cumulative.

3.5 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
   1. Periodic inspection during the installation of suspended ceiling grids according to ASCE/SEI 7.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections of completed installations of acoustical panel ceiling hangers and anchors and fasteners in successive stages and when installation of ceiling suspension systems on each floor has reached 20 percent completion, but no panels have been installed. Do not proceed with installations of acoustical panel ceiling hangers for the next area until test results for previously completed installations of acoustical panel ceiling hangers show compliance with requirements.
   1. Within each test area, testing agency will select one of every 10 power-actuated fasteners and postinstalled anchors used to attach hangers to concrete and will test them for 200 lbf of tension; it will also select one of every two postinstalled anchors used to attach bracing wires to concrete and will test them for 440 lbf of tension.
   2. When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 pass consecutively and then will resume initial testing frequency.

D. Acoustical panel ceiling hangers, anchors, and fasteners will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 CLEANING

A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension-system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage.

B. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.
END OF SECTION
SECTION 095423 - SUSPENDED METAL CEILINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes suspended metal ceiling baffles and suspension systems.

1.3 DEFINITIONS
A. NRC: Noise Reduction Coefficient.

1.4 COORDINATION
A. Coordinate layout and installation of suspended metal ceiling and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

1.5 ACTION SUBMITTALS
A. Product Data: For each type of product.
B. Sustainable Design Submittals required by Section 01813 applicable to this Section.
C. Samples for Initial Selection: Manufacturer's available finishes for selection of wood grain.
D. Samples for Verification: For each component indicated and for each exposed finish required, prepared on Samples of size indicated below:
   1. Suspended Metal Baffle: Set of 12-inch- long Samples of each type and color and a 12-inch- long spliced section.
   2. Exposed Molding and Trim: Set of 12-inch- long Samples of each type, finish, and color.

1.6 INFORMATIONAL SUBMITTALS
A. Evaluation Reports: For each suspended metal ceiling suspension system and anchor and fastener type, from ICC-ES.
B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended pattern.
   2. Joint pattern.
3. Ceiling suspension members.
4. Method of attaching hangers to building structure.
   a. Furnish layouts for cast-in-place anchors, clips, and other ceiling attachment
devices whose installation is specified in other Sections.
5. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, and
access panels.
6. Ceiling perimeter and penetrations through ceiling; trim and moldings.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For finishes to include in maintenance manuals.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by National Voluntary Laboratory Accreditation
Program for testing indicated.

B. Provide the following upon request:
   1. Qualification Data: For testing agency.
   2. Product Test Reports: For each suspended metal ceiling, for tests performed by a
      qualified testing agency.
   3. Field quality-control reports.

C. Mockups: Build in-place mockup to verify selections made under Sample submittals and to
demonstrate aesthetic effects and to set quality standards for materials and execution.
   1. Build mockup of typical ceiling area as shown on Drawings, not less than 100 sq. ft..
   2. Approval of mockups does not constitute approval of deviations from the Contract
      Documents contained in mockups unless Architect specifically approves such deviations
      in writing.
   3. Subject to compliance with requirements, approved mockups may become part of the
      completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver suspended metal ceiling, suspension system components, and accessories to Project
site in original, unopened packages and store them in a fully enclosed, conditioned space where
they are protected against damage from moisture, humidity, temperature extremes, direct
sunlight, surface contamination, and other causes.

B. Handle suspended metal ceiling, suspension system components, and accessories carefully to
avoid damaging units and finishes in any way.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Do not install suspended metal ceilings until spaces are enclosed
and weathertight, wet work in spaces is complete and dry, work above ceilings is complete, and
ambient temperature and humidity conditions are maintained at the levels indicated for Project
when occupied for its intended use.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain each type of metal ceiling panel and supporting suspension system from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Suspended ceiling installation has been designed to withstand the effects of earthquake motions determined according to ASCE/SEI 7 as amended by 2016 CBC Section 1616.10.16 and Section 1616A.1.21.

B. Recycled Content of Metal Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

C. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: Comply with ASTM E 1264 for Class A materials.
   2. Smoke-Developed Index: 450 or less.

2.3 SUSPENDED METAL CEILING PANELS

A. Suspended Metal Baffles and Suspension System, Type BC-1:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings as manufactured by Ceilings Plus, or comparable product by one of the following below, BC-1 fastens to metal suspension system, refer to Drawings and article 2.4.A.
      a. Armstrong Ceiling
      b. Architectural Components Group
   2. Panel Edge Detail: Manufacturer's standard edge detail.
   3. Panel Face Width: As indicated on Drawings.
   5. End Cap, Finish of Exposed Portions: To match pan.
   6. NRC: Not less than 0.75.

B. Sheet Metal Characteristics: For metal components exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, roughness, stains, or discolorations.
   1. Aluminum Sheet: Brake formed aluminum sheet, complying with ASTM B 209; alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.

C. Panel Fabrication: Manufacturer's standard units of size, profile, and edge treatment indicated, formed from metal indicated to snap on and be securely retained on carriers without separate fasteners, and finished to comply with requirements indicated.

D. Panel Splices: Construction same as ceiling, in lengths 8 to 12 inches; with manufacturer's standard finish.

E. End Caps: Metal matching ceiling; fabricated to fit and conceal exposed ends of ceiling.
F.  Filler Strips: Metal matching ceiling; fabricated to uninterruptedly close voids between ceiling.

G.  Moldings and Trim: Provide manufacturer's standard moldings and trim for exposed members, and as indicated or required, for edges and penetrations of ceiling, around fixtures, at changes in ceiling height, and for other conditions; of same metal and finish as suspended metal ceiling.

H.  Sound-Absorbent Fabric Layer: Provide fabric layer, sized to fit concealed surface of pan, and consisting of black, nonwoven, nonflammable, sound-absorbent material with surface-burning characteristics for flame-spread index of 25 or less and smoke-developed index of 50 or less, as determined by testing per ASTM E 84.
   1. Bond fabric layer to baffle in the factory with manufacturer's standard nonflammable adhesive.

2.4 METAL SUSPENSION SYSTEM

A.  Metal Suspension Systems Standard: Provide ceiling manufacturer's standard metal suspension systems of types and finishes indicated that comply with applicable ASTM C 635/C 635M requirements.
   A. USG - ESR 1222
   B. Armstrong - ESR 1308

B.  Suspension Systems: Provide metal ceiling manufacturer's standard torsion spring systems complete with carriers, splice sections, connector clips, alignment clips, leveling clips, hangers, molding, trim, retention clips, load-resisting struts, fixture adapters, and other suspension components required to support ceiling units and other ceiling-supported construction.

C.  Attachment Devices: Provide as indicated in accordance with ASTM C 635. Refer to Drawings for specific requirements and spacing.
   1. Anchors: Anchors of type and material indicated.
      a. Product: Refer to Drawings.
         1) Corrosion Protection: Carbon-steel components zinc plated according to ASTM B 633, Class SC 1 (mild) service condition.
   2. Power-Actuated Fasteners: Fastener system as indicated.

D.  Wire Hangers, Braces, and Ties: Provide wires as follows:
   2. Size: Wire diameter sufficient for its stress at three times hanger design load (ASTM C 635/C 635M, Table 1, "Direct Hung") will be less than yield stress of wire, but not less than 0.106-inch-diameter wire.
      3. Size:
         a. Hanger Wire Size: 0.106 inch (No. 12-gauge) diameter wire.
         b. Seismic Bracing Wire Size: 0.106 inch (No. 12-gauge) diameter wire.

E.  Hanger Rods: Mild steel, zinc coated or protected with rust-inhibitive paint.

F.  Flat Hangers: Mild steel, zinc coated or protected with rust-inhibitive paint.

G.  Angle Hangers: Angles with legs not less than 7/8 inch wide; formed from 0.04-inch-thick, galvanized-steel sheet complying with ASTM A 653/A 653M, G90 coating designation; with bolted connections and 5/16-inch-diameter bolts.

1. Main Carriers: Aluminum, not less than 0.240-inch rolled sheet, alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, complying with ASTM B 209.

I. Carrier Splices: Same metal, profile, and finish as for carriers.

J. Stabilizer Channels, Tees, and Bars: Manufacturer's standard components for stabilizing main carriers at regular intervals and at light fixtures, air-distribution equipment, access doors, and other equipment; spaced as standard with manufacturer for use indicated; and factory finished with matte-black baked finish.

K. Hold-Down Clips: Manufacturer's standard hold-down clip spaced as standard with manufacturer. Provide on ceilings within 20'-0" feet of exterior openings.

L. Seismic Clips: Manufacturer’s standard seismic clips designed to secure acoustical panels in place during a seismic event.
   1. Location and Spacing: As recommended by manufacturer. Refer to Drawings.

M. Seismic Stabilizer Bars: Manufacturer's standard perimeter stabilizers designed to accommodate seismic forces.
   1. Location and Spacing: As recommended by manufacturer. Refer to Drawings.

N. Seismic Struts: Manufacturer’s standard compression struts designed to accommodate seismic forces.
   1. Location and Spacing: As recommended by manufacturer. Refer to Drawings.

2.5 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 ALUMINUM FINISHES

A. PVC-Free simulated wood-grained laminate, or comparable wood-grained veneer or film.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, including structural framing and substrates to which suspended metal ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of suspended metal ceilings.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Measure each ceiling area and establish layout of suspended metal ceiling to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width ceiling at borders, and comply with layout shown on reflected ceiling plans and on Coordination Drawings.

3.3 INSTALLATION

A. Install acoustical panel ceilings according to ASTM C 636/C 636M, seismic design requirements, and manufacturer's written instructions.

1. Seismic Design Requirements: Install in accordance with the following:
   a. ASTM E 580/E 580M for Seismic Design Categories D, E, and F.
   b. ASTM E 580/E580M Section 5 as amended by 2016 CBC Section 1616.10.16 and Section 1616A.1.21.

B. Suspend ceiling hangers from building's structural members and as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
2. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
   a. When required, do not splay hangers steeper than 1:6 as described in DSA IR 25.2.
3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
4. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure and appropriate for substrate to which hangers are attached and for type of hanger involved.
5. Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both structure to which hangers are attached and type of hanger involved. Install hangers in a manner that does not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.
6. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
7. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
8. Do not attach hangers to steel deck tabs.
9. Do not attach hangers to steel roof deck. Attach hangers to structural members.
10. Space hangers not more than 48 inches o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches from ends of each member.
11. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.
C. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers but without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.

D. Install edge moldings and trim of type indicated at perimeter of suspended metal ceiling area and where necessary to conceal edges and ends of suspended metal ceiling.
   1. Do not use exposed fasteners, including pop rivets, on moldings and trim.

E. Install suspension system carriers so they are aligned and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

F. Cut suspended metal ceiling for accurate fit at borders and at interruptions and penetrations by other work through ceilings. Stiffen edges of cut units as required to eliminate evidence of buckling or variations in flatness exceeding referenced standards for stretcher-leveled metal sheet.

G. Install suspended metal ceiling in coordination with suspension system and exposed moldings and trim.
   1. Align joints in adjacent courses to form uniform, straight joints parallel to room axis in both directions unless otherwise indicated.
   2. Fit adjoining units to form flush, tight joints. Scribe and cut units for accurate fit at borders and around construction penetrating ceiling.
   3. If required by configuration and product limitations, install ceiling with butt joints using internal ceilingplies and in the following joint configuration:
      a. Staggered a minimum of 12 inches.
   4. Install directionally textured metal ceiling in directions indicated.
   5. Where metal pan ends are visible, install end caps unless trim is indicated.
   6. Install filler strips where indicated.

H. Install hold-down clips as required

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
   1. Suspended ceiling system.
   2. Hangers, anchors, and fasteners.

B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

C. Tests and Inspections: Testing and inspecting of completed installations of suspended metal ceiling hangers and anchors and fasteners shall take place in successive stages, in areas of extent and using methods as follows. Do not proceed with installations of suspended metal ceiling hangers for the next area until test results for previously completed installations show compliance with requirements.
   1. Extent of Each Test Area: When installation of ceiling suspension systems on each floor has reached 20 percent completion but no panels have been installed.
a. Within each test area, testing agency will select 1 of every 10 power-actuated fasteners and postinstalled anchors used to attach hangers to concrete and will test them for 200 lb of tension; it will also select 1 of every 2 postinstalled anchors used to attach bracing wires to concrete and will test them for 440 lb of tension.

b. When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 pass consecutively and then will resume initial testing frequency.

D. Suspended metal ceiling hangers and anchors and fasteners will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 CLEANING

A. Clean exposed surfaces of suspended metal ceilings, including trim and edge moldings after removing strippable, temporary protective covering if any. Comply with manufacturer’s written instructions for stripping of temporary protective covering, cleaning, and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage, including dented and bent units.
SECTION 096513 - RESILIENT BASE AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Resilient base.
   2. Resilient molding accessories.
   3. Metal transition strips.

B. Related Requirements:
   1. Section 090561.13 "Moisture Vapor Emission Control."

1.3 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal and Samples submittal. Ensure compliance with requirements included in Section 090413.

B. Product Data: For each type of product.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Samples for Verification: For each type of product indicated and for each color, texture, and pattern required in manufacturer's standard-size Samples, but not less than 12 inches long.

E. Product Schedule: For resilient base and accessory products.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Furnish not less than 10 linear feet for every 500 linear feet or fraction thereof, of each type, color, pattern, and size of resilient product installed.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store resilient products and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F or more than 90 deg F.
1.6 FIELD CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F or more than 95 deg F, in spaces to receive resilient products during the following time periods:
   1. 48 hours before installation.
   2. During installation.
   3. 48 hours after installation.

B. After installation and until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F or more than 95 deg F.

C. Install resilient products after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. FloorScore Compliance: Resilient base shall comply with requirements of FloorScore certification.

B. Resilient base shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.2 THERMOSET-RUBBER BASE

A. Basis-of-Design Products: Subject to compliance with requirements, provide products as manufactured by Johnsonite; A Tarkett Company, or comparable by one of the following:
   1. Burke Mercer Flooring Products, Division of Burke Industries Inc.
   2. Flexco.
   3. Nora Rubber Products
   4. Roppe Corporation, USA.

B. Product Standard: ASTM F 1861, Type TS (rubber, vulcanized thermoset), Group I (solid, homogeneous).
   1. Style and Location:
      a. RB-1: Straight: Provide in areas with carpet.
      b. RB-2, Cove: Provide in public areas and non-carpeted areas.
      c. RB-3: Provide in back-of-house areas.
   2. Thickness: 0.125 inch.
   3. Height: 4 inches.
   4. Lengths: Cut lengths 48 inches long or coils in manufacturer's standard length.
   5. Outside Corners: Preformed.
   6. Inside Corners: Job formed or preformed.
   7. Colors: As indicated by manufacturer's designations.
2.3 RUBBER MOLDING ACCESSORY

A. Description: Rubber carpet edge for glue-down applications nosing for carpet nosing for resilient flooring reducer strip for resilient flooring joiner for tile and carpet transition strips.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Johnsonite; A Tarkett Company.
   b. Roppe Corporation, USA.
   c. VPI, LLC, Floor Products Division.

2. Profile and Dimensions: As indicated.
3. Locations: Provide rubber molding accessories in areas indicated.
4. Colors and Patterns: As selected by Architect from full range of industry colors.

2.4 METAL TRANSITION STRIPS

A. Metal Edge/Transition Strips: Extruded aluminum with clear anodized finish of profile and width shown, of height required to protect exposed edge of carpet, and of maximum lengths to minimize running joints.

1. Product: Subject to compliance with requirements, provide products by one of the following to suit conditions:
   a. Progress Profiles
   b. Schluter Systems

2.5 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based or blended hydraulic-cement-based formulation provided or approved by resilient-product manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by resilient-product manufacturer for resilient products and substrate conditions indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of resilient products.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Installation of resilient products indicates acceptance of surfaces and conditions.
3.2 PREPARATION

A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of resilient products.

B. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.

C. Do not install resilient products until they are the same temperature as the space where they are to be installed.
   1. At least 48 hours in advance of installation, move resilient products and installation materials into spaces where they will be installed.

D. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient products.

3.3 RESILIENT BASE INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient base.

B. Apply resilient base to walls, columns, pilasters, casework and cabinets in toe spaces, and other permanent fixtures in rooms and areas where base is required.

C. Install resilient base in lengths as long as practical without gaps at seams and with tops of adjacent pieces aligned.

D. Tightly adhere resilient base to substrate throughout length of each piece, with base in continuous contact with horizontal and vertical substrates.

E. Do not stretch resilient base during installation.

F. On masonry surfaces or other similar irregular substrates, fill voids along top edge of resilient base with manufacturer's recommended adhesive filler material.

G. Preformed Corners: Install preformed corners before installing straight pieces.

H. Job-Formed Corners:
   1. Inside Corners: Use straight pieces of maximum lengths possible and form with returns not less than 3 inches in length.
      a. Miter or cope corners to minimize open joints.

3.4 RESILIENT ACCESSORY INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient accessories.

B. Resilient Molding Accessories: Butt to adjacent materials and tightly adhere to substrates throughout length of each piece. Install reducer strips at edges of floor covering that would otherwise be exposed.
3.5 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protecting resilient products.

B. Perform the following operations immediately after completing resilient-product installation:
   1. Remove adhesive and other blemishes from exposed surfaces.
   2. Sweep and vacuum horizontal surfaces thoroughly.
   3. Damp-mop horizontal surfaces to remove marks and soil.

C. Protect resilient products from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

END OF SECTION
SECTION 096516 - RESILIENT SHEET FLOORING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary
      Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes rubber sheet flooring.
   B. Related Requirements:
      1. Section 090561.13 "Moisture Vapor Emission Control."
      2. Section 096513 "Resilient Base and Accessories" for resilient base, reducer strips, and
         other accessories installed with resilient sheet floor coverings.

1.3 ACTION SUBMITTALS
   A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance
      Form may be submitted in lieu of required Product Data submittal and Samples submittal.
      Ensure compliance with requirements included in Section 090413.
   B. Product Data: For each type of product.
   C. Sustainable Design Submittals required by Section 01813 applicable to this Section.
   D. Shop Drawings: For each type of flooring. Include flooring layouts, locations of seams,
      edges, columns, doorways, enclosing partitions, built-in furniture, cabinets, and cutouts.
      1. Show details of special patterns.
   E. Samples for Initial Selection:
      1. For heat-welding bead, manufacturer's standard-size Samples of each color available.
   F. Samples for Verification: In manufacturer's standard size, but not less than 6-by-9-inch
      (150-by-230-mm) sections of each different color and pattern of resilient sheet flooring required.
   G. Welded-Seam Samples: For seamless-installation technique indicated and for each resilient
      sheet flooring product, color, and pattern and selected welding bead color required; with seam
      running lengthwise and in center of 6-by-9-inch Sample applied to a rigid backing and prepared
      by Installer for this Project.
   H. Product Schedule: For resilient sheet flooring. Use same designations indicated on
      Drawings.
1.4 INFORMATIONAL SUBMITTALS

A. Certifications: Submit a certification signed by the manufacturer and installer stating that the resilient flooring has been installed as specified and in accordance with fire-test response characteristics.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each type of resilient sheet flooring to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Resilient Sheet Flooring: Furnish not less than 10 linear feet for every 500 linear feet or fraction thereof, in roll form and in full roll width for each type, color, and pattern of flooring installed.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs workers for this Project who are competent in techniques required by manufacturer for resilient sheet flooring installation and seaming method indicated.

1. Engage an installer who employs workers for this Project who are trained or certified by resilient sheet flooring manufacturer for installation techniques required.

B. Provide the following upon request;

1. Qualification Data: For Installer.

C. Mockups: Build in-place mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockups for resilient sheet flooring including resilient base and accessories.
   a. Size: Minimum 100 sq. ft. for each type, color and pattern in locations directed by Architect.

2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store resilient sheet flooring and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F or more than 90 deg F. Store rolls upright.
1.9 FIELD CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F or more than 85 deg F, in spaces to receive resilient sheet flooring during the following time periods:
   1. 48 hours before installation.
   2. During installation.
   3. 48 hours after installation.

B. After installation and until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F or more than 95 deg F.

C. Close spaces to traffic during resilient sheet flooring installation.

D. Close spaces to traffic for 48 hours after resilient sheet flooring installation.

E. Install resilient sheet flooring after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: For resilient sheet flooring, as determined by testing identical products according to ASTM E 648 or NFPA 253 by a qualified testing agency.
   1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

B. FloorScore Compliance: Resilient sheet flooring shall comply with requirements of FloorScore certification.

C. Flooring products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.2 RUBBER SHEET FLOORING

A. Basis-of-Design Products: Subject to compliance with requirements, provide products as indicated on Drawings, or comparable by one of the listed manufacturers.

B. Sheet Width: As standard with manufacturer.

C. Colors and Patterns: As indicated on Drawings by manufacturer's designations.

2.3 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based or blended hydraulic-cement-based formulation provided or approved by resilient sheet flooring manufacturer for applications indicated.
B. Adhesives: Water-resistant type recommended by flooring and adhesive manufacturers to suit resilient sheet flooring and substrate conditions indicated.

C. Seamless-Installation Accessories:
      a. Color: As selected by Architect from manufacturer's full range.

D. Integral-Flash-Cove-Base Accessories:
   1. Cove Strip: 1-inch radius provided or approved by resilient sheet flooring manufacturer.
   2. Cap Strip: Tapered rubber cap provided or approved by resilient sheet flooring manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
   1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of resilient sheet flooring.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrates according to resilient sheet flooring manufacturer's written instructions to ensure adhesion of resilient sheet flooring.

B. Concrete Substrates: Prepare according to ASTM F 710.
   1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
   2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by resilient sheet flooring manufacturer. Do not use solvents.
   3. Alkalinity and Adhesion Testing: Perform tests recommended by resilient sheet flooring manufacturer. Proceed with installation only after substrate alkalinity falls within range on pH scale recommended by manufacturer in writing, but not less than 5 or more than 10 pH.
   4. Moisture Testing: Proceed with installation only after substrates pass testing according to resilient sheet flooring manufacturer's written recommendations, but not less stringent than the following:
      a. Perform anhydrous calcium chloride test according to ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. in 24 hours.
      b. Perform relative humidity test using in situ probes according to ASTM F 2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level.
      c. If water moisture tests exceed stated limits, apply vapor retarder for moisture vapor emission control as specified in Section 090561.13.
C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install resilient sheet flooring until it is the same temperature as the space where it is to be installed.
   1. At least 48 hours in advance of installation, move flooring and installation materials into spaces where they will be installed.

E. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient sheet flooring.

3.3 RESILIENT SHEET FLOORING INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient sheet flooring.

B. Unroll resilient sheet flooring and allow it to stabilize before cutting and fitting.

C. Lay out resilient sheet flooring as follows:
   1. Maintain uniformity of flooring direction.
   2. Minimize number of seams; place seams in inconspicuous and low-traffic areas, at least 6 inches away from parallel joints in flooring substrates.
   3. Match edges of flooring for color shading at seams.
   4. Avoid cross seams.

D. Scribe and cut resilient sheet flooring to butt neatly and tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, and door frames.

E. Extend resilient sheet flooring into toe spaces, door reveals, closets, and similar openings.

F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on resilient sheet flooring as marked on substrates. Use chalk or other nonpermanent marking device.

G. Install resilient sheet flooring on covers for telephone and electrical ducts and similar items in installation areas. Maintain overall continuity of color and pattern between pieces of flooring installed on covers and adjoining flooring. Tightly adhere flooring edges to substrates that abut covers and to cover perimeters.

H. Adhere resilient sheet flooring to substrates using a full spread of adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.


3.4 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protecting resilient sheet flooring.

B. Perform the following operations immediately after completing resilient sheet flooring installation:
1. Remove adhesive and other blemishes from surfaces.
2. Sweep and vacuum surfaces thoroughly.
3. Damp-mop surfaces to remove marks and soil.

C. Protect resilient sheet flooring from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

D. Cover resilient sheet flooring until Substantial Completion.

END OF SECTION
SECTION 096519 - RESILIENT TILE FLOORING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Solid luxury vinyl floor tile.

B. Related Requirements:
   1. Section 090561.13 "Moisture Vapor Emission Control."
   2. Section 096513 "Resilient Base and Accessories" for resilient base, reducer strips, and other accessories installed with resilient floor tile coverings.

1.3 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal and Samples submittal. Ensure compliance with requirements included in Section 013300 "Submittal Procedures."

B. Product Data: For each type of product.

C. Sustainable Design Submittals:
   1. Product Data: For adhesives, indicating VOC content.
   2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
   3. Product Data: For chemical-bonding compounds, indicating VOC content.
   4. Product Data: For recycled content.
   5. Laboratory Test Reports: For chemical-bonding compounds, indicating compliance with requirements for low-emitting materials.
   6. Product Data: For sealants, indicating VOC content.
   7. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
   8. Laboratory Test Reports: For flooring products, indicating compliance with requirements for low-emitting materials.

D. Shop Drawings: For each type of floor tile. Include floor tile layouts, edges, columns, doorways, enclosing partitions, built-in furniture, cabinets, and cutouts.
   1. Show details of special patterns.

E. Samples for Verification: Full-size units of each color and pattern of floor tile required.
1.4 INFORMATIONAL SUBMITTALS

A. Certifications: Submit a certification signed by the manufacturer and installer stating that the resilient flooring has been installed as specified and in accordance with fire-test response characteristics.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each type of floor tile to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Floor Tile: Furnish one box for every 50 boxes or fraction thereof, of each type, color, and pattern of floor tile installed.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs workers for this Project who are competent in techniques required by manufacturer for floor tile installation and seaming method indicated.
   1. Engage an installer who employs workers for this Project who are trained or certified by floor tile manufacturer for installation techniques required.

B. Provide the following upon request:
   1. Qualification Data: For Installer.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store floor tile and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F or more than 90 deg F. Store floor tiles on flat surfaces.

1.9 FIELD CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F or more than 95 deg F, in spaces to receive floor tile during the following time periods:
   1. 48 hours before installation.
   2. During installation.
   3. 48 hours after installation.

B. After installation and until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F or more than 95 deg F.

C. Close spaces to traffic during floor tile installation.

D. Close spaces to traffic for 48 hours after floor tile installation.
E. Install floor tile after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: For resilient tile flooring, as determined by testing identical products according to ASTM E 648 or NFPA 253 by a qualified testing agency.
   1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

B. FloorScore Compliance: Resilient tile flooring shall comply with requirements of FloorScore certification.

C. Flooring products shall comply with requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.2 SOLID LUXURY VINYL FLOOR TILE

A. Basis-of-Design Products: Subject to compliance with requirements, products indicated on the Drawings, or Architect approved equal.
   1. Colors and Patterns: As indicated by on Drawings manufacturer's designations.

2.3 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement based or blended hydraulic-cement-based formulation provided or approved by floor tile manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by floor tile and adhesive manufacturers to suit floor tile and substrate conditions indicated.
   1. Adhesives shall have a VOC content of 50 g/L or less.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
   1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of floor tile.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 PREPARATION

A. Prepare substrates according to floor tile manufacturer’s written instructions to ensure adhesion of resilient products.

B. Concrete Substrates: Prepare according to ASTM F 710.
   1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
   2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by floor tile manufacturer. Do not use solvents.
   3. Alkalinity and Adhesion Testing: Perform tests recommended by floor tile manufacturer. Proceed with installation only after substrate alkalinity falls within range on pH scale recommended by manufacturer in writing, but not less than 5 or more than 9 pH.
   4. Moisture Testing: Proceed with installation only after substrates pass testing according to floor tile manufacturer’s written recommendations, but not less stringent than the following:
      a. Perform anhydrous calcium chloride test according to ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. in 24 hours.
      b. Perform relative humidity test using in situ probes according to ASTM F 2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level.
   5. If water moisture tests exceed stated limits, apply vapor retarder for moisture vapor emission control as specified in Section 090561.13.

C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install floor tiles until they are the same temperature as the space where they are to be installed.
   1. At least 48 hours in advance of installation, move resilient floor tile and installation materials into spaces where they will be installed.

E. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient floor tile.

3.3 FLOOR TILE INSTALLATION

A. Comply with manufacturer's written instructions for installing floor tile.

B. Lay out floor tiles from center marks established with principal walls, discounting minor offsets, so tiles at opposite edges of room are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half tile at perimeter.
   1. Lay tiles square with room axis.

C. Match floor tiles for color and pattern by selecting tiles from cartons in the same sequence as manufactured and packaged, if so numbered. Discard broken, cracked, chipped, or deformed tiles.
   1. Lay tiles with grain direction alternating in adjacent tiles (basket-weave pattern).

D. Scribe, cut, and fit floor tiles to butt neatly and tightly to vertical surfaces and permanent fixtures.
including built-in furniture, cabinets, pipes, outlets, and door frames.

E. Extend floor tiles into toe spaces, door reveals, closets, and similar openings. Extend floor tiles to center of door openings.

F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on floor tiles as marked on substrates. Use chalk or other nonpermanent marking device.

G. Adhere floor tiles to flooring substrates using a full spread of adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.

3.4 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protecting floor tile.

B. Perform the following operations immediately after completing floor tile installation:
   1. Remove adhesive and other blemishes from exposed surfaces.
   2. Sweep and vacuum surfaces thoroughly.
   3. Damp-mop surfaces to remove marks and soil.

C. Protect floor tile from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

D. Cover floor tile until Substantial Completion.

END OF SECTION
SECTION 096723 - RESINOUS FLOORING AND WALL COATINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes resinous flooring and wall coating systems.

1.2 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal and Samples submittal. Ensure compliance with requirements included in Section 013300 "Submittal Procedures."

B. Product Data: For each type of product. Include manufacturer's technical data, application instructions, and recommendations for each resinous coating system component required.

C. Sustainable Design Submittals in accordance with Section 01813 "Sustainable Design Requirements" applicable to this Section.

D. Samples for Initial Selection: For each floor and wall coating resin color and quartz additive for Architects selection.

E. Samples for Verification: For each resinous coating system required, 6 inches square, applied to a rigid backing by Installer for this Project.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance Data: For resinous flooring and wall coatings to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained or approved by coating manufacturer.

B. Manufacturer Field Technical Service Representatives: Resinous coating manufacturer's technical field representative who is trained specifically on installing the system to be used on the project shall be available to assist in the quality assurance and quality control process of the installation and shall be available to perform field problem solving issues with the installer.

C. Provide the following upon request:
   1. Installer Certificates: Signed by manufacturer certifying that installers comply with specified requirements.
   2. Material Test Reports: For each resinous coating systems, by a qualified testing agency.

D. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Apply full-thickness mockups on 48-inch- square floor area selected by Architect.
RESINOUS FLOORING AND WALL COATINGS

1. Include 48-inch length of integral cove base with inside and outside corner.

2. Simulate finished lighting conditions for Architect's review of mockups.

3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in original packages and containers, with seals unbroken, bearing manufacturer's labels indicating brand name and directions for storage and mixing with other components.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Comply with resinous coating manufacturer's written instructions for substrate temperature, ambient temperature, moisture, ventilation, and other conditions affecting resinous coating application.

B. Lighting: Provide permanent lighting or, if permanent lighting is not in place, simulate permanent lighting conditions during resinous coating application.

C. Close spaces to traffic during resinous flooring application and for 24 hours after application unless manufacturer recommends a longer period.

D. Provide adequate ventilation.

E. Mask off floor drain outlets.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. VOC Content of Liquid-Applied Resinous Coating Components: Not more than 100 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Flammability: Self-extinguishing according to ASTM D 635.

2.2 MANUFACTURERS

A. Source Limitations: Obtain primary resinous flooring and wall coating materials, including primers, resins, hardening agents, and decorative aggregate from single source from single manufacturer. Obtain secondary materials, including patching and fill material, joint sealant, and repair materials, of type and from manufacturer recommended in writing by manufacturer of primary materials.
2.3 RESINOUS FLOORING

A. Resinous Flooring System, Type RESF-1: Abrasion-, impact-, and chemical-resistant, decorative-aggregate-filled, and resin-based monolithic slip-resistant floor surfacing designed to produce a seamless floor, with integral cove base.

1. Basis-of-Design Product: Subject to compliance with requirements, provide SeamTek Type 3 Epoxy Quartz Flooring System as manufactured by Life Science Products, Inc., or Architect approved equal by one of the following:
   a. Sika Corporation.
   b. General Polymers.

B. Primer: Type recommended by resinous coating manufacturer for substrate and resinous flooring system indicated.

C. Waterproofing Membrane: Type recommended by resinous coating manufacturer for substrate and resinous flooring system indicated.

D. Undercoat: 100 percent epoxy.
   1. Resin: Two-component epoxy.
      a. Color: As selected by Architect from manufacturer's available colors.
   2. Number of Coats: One.
   3. Aggregates: Decorative ceramic coated quartz blends.
      a. Color: As selected by Architect from manufacturer's available colors.

E. Topcoat/Sealer Coat: Chemical resistant, UV stable, 100 percent epoxy sealing and finish coat.
   1. Resin: Two-component epoxy.
   2. Type: Clear.
   3. Number of Coats: One.
   4. Thickness of Coat: As instructed by manufacturer.

F. Integral Cove Base: High performance, coating consisting of epoxy resin, curing agent and selected, graded aggregates, 100 percent epoxy mortar system; 3/4 inch cove.

G. System Physical Properties: Provide resinous flooring system with the following minimum physical property requirements when tested according to test methods indicated:
   1. Compressive Strength: 11000 psi minimum according to ASTM C 579, 7-day.
   2. Tensile Strength: 2400 minimum according to ASTM C 307.
   3. Flexural Strength: 4000 psi minimum according to ASTM C 580.
   4. Impact Resistance: No chipping, cracking, or delamination at 160 in/lbs according to ASTM D 2794 and not more than 1/16-inch permanent indentation according to MIL-D-3134J.
   5. Abrasion Resistance: 0.03 gm. maximum weight loss according to ASTM D 4060.
   6. Hardness: 80 minimum, Shore D according to ASTM D 2240.
   7. Resistance to Heat: Delta E>8 according to ASTM F 970.
   8. Noise Reduction Coefficient: 0.05 per ASTM C 423.

2.4 RESINOUS WALL COATING

A. Resinous Wall Coating System, Type RESW-1: Abrasion-, impact-, and chemical-resistant,
solvent-free resin-based monolithic wall surfacing.

1. Basis-of-Design Product: Subject to compliance with requirements, provide SeamTek Epoxy GlassWall NR as manufactured by Life Science Products, Inc., or Architect approved equal.

B. System Characteristics:

1. Color: As selected by Architect from manufacturer's available colors.
2. Overall System Thickness: 12- to 15-mils dry, not including primer.

C. Primer: Type recommended by resinous coating manufacturer for substrate indicated.

D. Topcoat: 100 percent epoxy, compatible with flooring product by same manufacturer.

   1. Resin: Two-component epoxy.
   2. Type: Pigmented.
   3. Surface: Smooth, pinhole-free.

E. System Physical Properties: Provide resinous wall coating system with the following minimum physical property requirements when tested according to test methods indicated:

   1. Compressive Strength: 11000 psi minimum according to ASTM C 579, 7-day.
   2. Tensile Strength: 3000 minimum according to ASTM CD 638.
   3. Flexural Strength: 4000 psi minimum according to ASTM D 790.
   4. Abrasion Resistance: 0.035 gm. maximum weight loss according to ASTM D 4060.
   5. Hardness: 70 minimum, Shore D according to ASTM D 1706.
   7. Thermal Shock: No cracking or loss of adhesion according to MIL F 52505.

2.5 ACCESSORY MATERIALS

A. Patching and Leveling: Resinous epoxy-based grout designed for permanent repairs under specified flooring system. Use standard drain details, saw cut and chase.

B. Joint Sealant: Type recommended or produced by resinous coating manufacturer for type of service and joint condition indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine floor and wall surfaces in the presence of manufacturer's field representative.

B. Ensure floor drain inlets have been properly prepared for application of floor coating to protect drain piping from intrusion of resinous material that could cause drain to malfunction.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

D. Concrete Slabs: Verify that concrete substrates are dry and moisture-vapor emissions are within acceptable levels according to manufacturer's written instructions.
1. **Moisture Testing:** Perform tests so that each test area does not exceed 1000 sq. ft., and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.

   a. **Anhydrous Calcium Chloride Test:** ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. in 24 hours.

   b. **Relative Humidity Test:** Using in situ probes, ASTM F 2170. Proceed with installation only after substrates have a maximum 80 percent relative humidity level measurement.

   c. Perform additional moisture tests recommended by manufacturer. Proceed with installation only after substrates pass testing.

   d. If water moisture tests exceed stated limits, apply vapor retarder for moisture vapor emission control as specified in Section 090561.13.

3.2 **PREPARATION**

   A. Prepare and clean substrates according to resinous coating manufacturer's written instructions for substrate indicated. Provide clean, dry substrate for resinous coating application.

   B. **Concrete Substrates:** Provide sound concrete surfaces free of laitance, glaze, efflorescence, curing compounds, form-release agents, dust, dirt, grease, oil, and other contaminants incompatible with resinous flooring.

      1. Mechanically prepare substrates as follows:

         a. Shot-blast surfaces with an apparatus that abrades the concrete surface, contains the dispensed shot within the apparatus, and recirculates the shot by vacuum pickup or Diamond Grind with dust free system.

      2. Repair damaged and deteriorated concrete according to resinous flooring manufacturer's written recommendations.

      3. Verify that concrete substrates are dry.

   C. Perform additional moisture tests recommended by manufacturer. Proceed with application only after substrates pass testing. Use patching and fill material to fill holes and depressions in substrates according to manufacturer's written instructions.

   D. **Gypsum Board Substrates:** Paint ready.

   E. Treat control joints and other nonmoving substrate cracks to prevent cracks from reflecting through resinous coating according to manufacturer's written recommendations.

   F. **Resinous Materials:** Mix components and prepare materials according to resinous coating manufacturer's written instructions.

3.3 **RESINOUS COATING APPLICATION, GENERAL**

   A. **General:** Apply components of resinous floor and wall coating systems according to manufacturer's written instructions to produce a uniform, monolithic wearing surface of thickness indicated.

      1. Coordinate application of components to provide optimum adhesion of resinous coating system to substrate, and optimum intercoat adhesion.

      2. Cure resinous coating components according to manufacturer's written instructions. Prevent contamination during application and curing processes.
3. Expansion and Isolation Joint Treatment: At substrate expansion and isolation joints, comply with resinous coating manufacturer's written instructions.
   a. Apply joint sealant to comply with manufacturer's written instructions.

B. Begin coating application in the presence of coating manufacturer's technical field representative.

3.4 FLOORING APPLICATION

A. Begin coating application in the presence of coating manufacturer's technical field representative.

B. Apply primer and waterproofing coats over prepared substrate at manufacturer's recommended spreading rate wet on wet application.

C. Apply cove base mix to wall surfaces before applying flooring. Apply according to manufacturer's written instructions and details including those for taping, mixing, priming, troweling, and top coating of cove base. Round internal and external corners.

D. Undercoat: Mix and apply undercoat according to manufacturer's installation procedures and coverage rates. Allow to cure before applying topcoat.
   1. DFT: 3/16 inch thick
   2. Sanding: Broadcast aggregate to surface of undercoat to refusal according to manufacturer's written instructions as applicable to system specified. Thoroughly clean and vacuum surface once sanding has been completed. Allow to cure before applying topcoat. Omit decorative aggregate in vertical cove base.

E. Top Coat: Mix and apply topcoat according to manufacturer's installation procedures and coverage rates to achieve final dry thickness indicated, and allow to cure.

3.5 WALL APPLICATION

A. Begin coating application in the presence of coating manufacturer's technical field representative.

B. Apply primer over prepared substrate at manufacturer's recommended spreading rate wet on wet application.

C. Apply according to manufacturer's written instructions and details including those for taping, mixing, priming, troweling, and rolling as instructed.

3.6 TERMINATIONS

A. Scribe floor along lines of termination and chase edges to "lock" coating system into concrete substrate.

B. Penetration Treatment: Lap and seal coating onto the perimeter of the penetrating item by bridging over compatible elastomer at the interface to compensate for possible movement.

C. Trenches: Continue coating system into trenches to maintain monolithic protection. Treat cold joints to assure bridging of potential cracks.
D. Treat floor drains by chasing the coating to lock in place at point of termination.

3.7 JOINTS AND CRACKS

A. Treat control joints and to maintain monolithic protection.

B. Treat cold joints and construction joints to bridge potential cracks and to maintain monolithic protection on horizontal and vertical surfaces as well as horizontal and vertical interfaces.

C. Discontinue floor coating system at vertical and horizontal contraction and expansion joints by installing backer rod and compatible sealant after coating installation is completed. Provide sealant type instructed by manufacturer for traffic conditions and chemical exposures to be encountered.

3.8 CURING

A. Cure resinous flooring and wall materials in compliance with manufacturer's directions, taking care to prevent contamination during stages of application and prior to completion of curing process. Close area of application for a minimum of 24 hours.

3.9 CLEANING AND PROTECTION

A. Cleaning: Use cleaning materials and procedures recommended by resinous coating manufacturer during and immediately after installation.

B. Protection: Protect resinous flooring and wall coatings from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by resinous coating manufacturer.

C. Final Cleaning: Remove temporary covering and clean resinous flooring and wall coatings just prior to final inspection. Use cleaning materials and procedures recommended by resinous coating manufacturer.

END OF SECTION
SECTION 096813 - TILE CARPETING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes modular carpet tile.

B. Related Requirements:
   1. Section 090561.13 "Moisture Vapor Emission Control."
   2. Section 096513 "Resilient Base and Accessories" for resilient wall base and accessories installed with carpet tile.

1.3 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal and Samples submittal. Ensure compliance with requirements included in Section 090413.

B. Product Data: For each type of product.
   1. Include manufacturer's written data on physical characteristics, durability, and fade resistance.
   2. Include manufacturer's written installation recommendations for each type of substrate.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Shop Drawings: For carpet tile installation, plans showing the following:
   1. Columns, doorways, enclosing walls or partitions, built-in cabinets, and locations where cutouts are required in carpet tiles.
   2. Carpet tile type, color, and dye lot.
   3. Type of subfloor.
   4. Type of installation.
   5. Pattern of installation.
   6. Pattern type, location, and direction.
   7. Pile direction.
   8. Type, color, and location of edge, transition, and other accessory strips.
   9. Transition details to other flooring materials.

E. Samples for Verification: For each of the following products and for each color and texture required. Label each Sample with manufacturer's name, material description, color, pattern, and designation indicated on Drawings and in schedules.
   2. Exposed Edge, Transition, and Other Accessory Stripping: 12-inch-long Samples.
F. Product Schedule: For carpet tile. Use same designations indicated on Drawings.


1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For carpet tiles to include in maintenance manuals. Include the following:
   1. Methods for maintaining carpet tile, including cleaning and stain-removal products and procedures and manufacturer's recommended maintenance schedule.
   2. Precautions for cleaning materials and methods that could be detrimental to carpet tile.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Carpet Tile: Full-size units equal to 5 percent of amount installed for each type indicated, but not less than 10 sq. yd..

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who is certified by the International Certified Floorcovering Installers Association at the Commercial II certification level.

B. Provide the following upon request:
   1. Qualification Data: For Installer.
   2. Product Test Reports: For carpet tile, for tests performed by a qualified testing agency.

C. Mockups: Build in-place mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.
   1. Build mockups at locations and in sizes shown on Drawings; not less than 100 sq. ft..
   2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with CRI's "CRI Carpet Installation Standard."

1.8 FIELD CONDITIONS

A. Comply with CRI's "CRI Carpet Installation Standard" for temperature, humidity, and ventilation limitations.

B. Environmental Limitations: Do not deliver or install carpet tiles until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at levels planned for building occupants during the remainder of the construction period.
C. Do not install carpet tiles over concrete slabs until slabs have cured and are sufficiently dry to bond with adhesive and concrete slabs have pH range recommended by carpet tile manufacturer.

D. Where demountable partitions or other items are indicated for installation on top of carpet tiles, install carpet tiles before installing these items.

1.9 WARRANTY

A. Special Warranty for Carpet Tiles: Manufacturer agrees to repair or replace components of carpet tile installation that fail in materials or workmanship within specified warranty period.
   1. Warranty does not include deterioration or failure of carpet tile due to unusual traffic, failure of substrate, vandalism, or abuse.
   2. Failures include, but are not limited to, the following:
      a. More than 10 percent edge raveling, snags, and runs.
      b. Dimensional instability.
      c. Excess static discharge.
      d. Loss of tuft-bind strength.
      e. Loss of face fiber.
      f. Delamination.
   3. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CARPET TILE

A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings, or Architect approved equal.

C. Color: As indicated by manufacturer's designations.

D. Pattern: Match Architect's samples.

E. Pile Height: Not more than 1/2 inch according to CBC Title 24 Chapter 11B.

F. Primary Backing/Backcoating: Manufacturer's standard composite materials.

G. Applied Treatments:
   2. Antimicrobial Treatment: Manufacturer's standard treatment that protects carpet tiles as follows:
      a. Antimicrobial Activity: Not less than 2-mm halo of inhibition for gram-positive bacteria, not less than 1-mm halo of inhibition for gram-negative bacteria, and no fungal growth, according to AATCC 174.

H. Sustainable Design Requirements:
1. Sustainable Product Certification: Silver level certification according to ANSI/NSF 140.
2. Flooring products shall comply with the requirements of the California Department of Public Health’s “Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers.”

I. Performance Characteristics:
1. Appearance Retention Rating: Severe traffic, 3.5 minimum according to ASTM D 7330.
2. Critical Radiant Flux Classification: Not less than \[0.45 \text{ W/sq. cm} \] \[0.22 \text{ W/sq. cm}\] according to NFPA 253.
3. Dimensional Tolerance: Within \(1/32\) inch of specified size dimensions, as determined by physical measurement.
4. Electrostatic Propensity: Less than 3.5 kV according to AATCC 134.

2.2 INSTALLATION ACCESSORIES

A. Trowelable Leveling and Patching Compounds: Latex-modified, hydraulic-cement-based formulation provided or recommended by carpet tile manufacturer.

B. Adhesives: Water-resistant, mildew-resistant, nonstaining, pressure-sensitive type to suit products and subfloor conditions indicated, that comply with flammability requirements for installed carpet tile, and are recommended by carpet tile manufacturer for releasable installation.
1. Adhesives shall have a VOC content of 50 g/L or less.
2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health’s “Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers.”

C. Metal Edge/Transition Strips: Refer to Section 096513 "Resilient Base and Accessories."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for maximum moisture content, alkalinity range, installation tolerances, and other conditions affecting carpet tile performance.

B. Examine carpet tile for type, color, pattern, and potential defects.

C. Concrete Slabs: Verify that finishes comply with requirements specified in Section 033000 “Cast-in-Place Concrete” and that surfaces are free of cracks, ridges, depressions, scale, and foreign deposits.
1. Moisture Testing: Perform tests so that each test area does not exceed 1000 sq. ft., and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
   a. Anhydrous Calcium Chloride Test: ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. in 24 hours.
b. Relative Humidity Test: Using in situ probes, ASTM F 2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.

c. Perform additional moisture tests recommended in writing by adhesive and carpet tile manufacturers. Proceed with installation only after substrates pass testing.

d. If water moisture tests exceed stated limits, apply vapor retarder for moisture vapor emission control as specified in Section 090561.13.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. General: Comply with CRI's "Carpet Installation Standards" and with carpet tile manufacturer's written installation instructions for preparing substrates indicated to receive carpet tile.

B. Use trowelable leveling and patching compounds, according to manufacturer's written instructions, to fill cracks, holes, depressions, and protrusions in substrates. Fill or level cracks, holes and depressions 1/8 inch wide or wider, and protrusions more than 1/32 inch unless more stringent requirements are required by manufacturer's written instructions.

C. Concrete Substrates: Remove coatings, including curing compounds, and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, without using solvents. Use mechanical methods recommended in writing by adhesive and carpet tile manufacturers.

D. Broom and vacuum clean substrates to be covered immediately before installing carpet tile.

3.3 INSTALLATION

A. General: Comply with CRI's "CRI Carpet Installation Standard," Section 18, "Modular Carpet" and with carpet tile manufacturer's written installation instructions.

B. Installation Method: Glue down; install every tile with full-spread, releasable, pressure-sensitive adhesive.

C. Maintain dye-lot integrity. Do not mix dye lots in same area.

D. Maintain pile-direction patterns recommended in writing by carpet tile manufacturer.

E. Cut and fit carpet tile to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings. Bind or seal cut edges as recommended by carpet tile manufacturer.

F. Extend carpet tile into toe spaces, door reveals, closets, open-bottomed obstructions, removable flanges, alcoves, and similar openings.

G. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on carpet tile as marked on subfloor. Use nonpermanent, nonstaining marking device.

H. Install pattern parallel to walls and borders.
3.4 CLEANING AND PROTECTION

A. Perform the following operations immediately after installing carpet tile:
   1. Remove excess adhesive and other surface blemishes using cleaner recommended by carpet tile manufacturer.
   2. Remove yarns that protrude from carpet tile surface.

B. Protect installed carpet tile to comply with CRI's "Carpet Installation Standard," Section 20, "Protecting Indoor Installations."

C. Protect carpet tile against damage from construction operations and placement of equipment and fixtures during the remainder of construction period. Use protection methods indicated or recommended in writing by carpet tile manufacturer.

END OF SECTION
SECTION 097200 - WALL COVERINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Dry-erase writable wall covering.
   2. Acoustic wall carpeting.
   3. Linoleum sheet wall surfacing.

B. Related Requirements:
   1. Section 099123 "Interior Painting" for priming wall surfaces.

1.3 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal and Samples submittal. Ensure compliance with requirements included in Section 013300 "Submittal Procedures."

B. Product Data: For each type of product.
   1. Include data on physical characteristics, durability, fade resistance, and fire-test-response characteristics.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Samples: For each type of wall covering and for each color, pattern, texture, and finish specified, full width by 36-inch-long in size.
   1. Trim: 12 inch length

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For wall coverings to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Wall-Covering Materials: For each type, color, texture, and finish, full width by length to equal to 5 percent of amount installed.
1.6 QUALITY ASSURANCE

A. Provide the following upon request:
   1. Qualification Data: For testing agency.
   2. Product Test Reports: For each wall covering, for tests performed by a qualified testing agency.

B. Mockups: Build in-place mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and to set quality standards for installation.
   1. Build mockups for each type of wall covering on each substrate required. Comply with requirements in ASTM F 1141 for appearance shading characteristics; not less than 100 sq. ft..
   2. Obtain Architects approval of pattern orientation, seaming, quality of installation and aesthetic effects prior to commencement of remaining portion of work of this Section.
   3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Do not deliver or install wall coverings until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above ceilings is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at levels intended for occupants after Project completion during the remainder of the construction period.

B. Lighting: Do not install wall covering until lighting that matches conditions intended for occupants after Project completion is provided on the surfaces to receive wall covering.

C. Ventilation: Provide continuous ventilation during installation and for not less than the time recommended by wall-covering manufacturer for full drying or curing.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: As determined by testing identical wall coverings applied with identical adhesives to substrates according to test method indicated below by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
      a. Flame-Spread Index: 25 or less.
      b. Smoke-Developed Index: 450 or less.
### 2.2 DRY-ERASE WRITABLE WALL COVERING

A. **Basis-of-Design Product**, Keynote Type WWS-1: Subject to compliance with requirements, provide product indicated on Drawings or comparable product as indicated.

B. **Width**: 48 inches to 60 inches manufacturer's standard roll width.

C. **Installation Method**: Adhesive.

D. **Color**: As indicated.

### 2.3 WALL CARPETING

A. **Basis-of-Design Product**: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the listed manufacturers.

B. **Installation Method**: Adhesive.

C. **Pattern Direction**: Vertical, unless otherwise directed.

D. **Trim**: Manufacturer's standard; aluminum.

E. **Colors, Textures, and Patterns**: As indicated.

### 2.4 LINOLEUM SHEET WALL SURFACING

A. **Basis-of-Design Product**: Subject to compliance with requirements, provide "Bulletin Board" pinboard linoleum as manufactured by Forbo Flooring Systems, or Architect approved equal.

1. **Thickness**: 6.0 mm
2. **Size**: As indicated.
3. **Color**: As indicated on Drawings.
4. **Mounting**: As indicated on Drawings.

### 2.5 ACCESSORIES

A. **Adhesive**: Mildew-resistant, nonstaining, strippable adhesive, for use with specific wall covering and substrate application indicated and as recommended in writing by wall-covering manufacturer.

1. Adhesive shall have a VOC content of 50 g/L or less.

B. **Primer/Sealer**: Mildew resistant, complying with requirements in Section 099123 "Interior Painting" and recommended in writing by primer/sealer and wall-covering manufacturers for intended substrate.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for levelness, wall plumbness, maximum moisture content, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Comply with manufacturer's written instructions for surface preparation.

B. Clean substrates of substances that could impair bond of wall covering, including dirt, oil, grease, mold, mildew, and incompatible primers.

C. Prepare substrates to achieve a smooth, dry, clean, structurally sound surface free of flaking, unsound coatings, cracks, and defects.
   1. Moisture Content: Maximum of 5 percent on new plaster, concrete, and concrete masonry units when tested with an electronic moisture meter.
   2. Gypsum Board: Prime with primer as recommended in writing by primer/sealer manufacturer and wall-covering manufacturer.

D. Remove hardware and hardware accessories, electrical plates and covers, light fixture trims, and similar items.

E. Acclimatize wall-covering materials by removing them from packaging in the installation areas not less than 24 hours before installation.

3.3 WALL-COVERING INSTALLATION

A. Comply with wall-covering manufacturers' written installation instructions applicable to products and applications indicated.

B. Install strips in same order as cut from roll.
   1. For solid-color, even-texture, or random-match wall coverings, reverse every other strip.

C. Install wall covering without lifted or curling edges and without visible shrinkage.

D. Install seams vertical and plumb at least 6 inches from outside corners and 6 inches from inside corners unless a change of pattern or color exists at corner. Horizontal seams are not permitted.

E. Trim edges and seams for color uniformity, pattern match, and tight closure. Butt seams without overlaps or gaps between strips.

F. Fully bond wall covering to substrate. Remove air bubbles, wrinkles, blisters, and other defects.

G. Install trim.
3.4 CLEANING

A. Remove excess adhesive at seams, perimeter edges, and adjacent surfaces.

B. Use cleaning methods recommended in writing by wall-covering manufacturer.

C. Replace strips that cannot be cleaned.

D. Reinstall hardware and hardware accessories, electrical plates and covers, light fixture trims, and similar items.

END OF SECTION
SECTION 098100 - ACOUSTICAL INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Acoustical Insulation in sound rated partitions.
   2. Acoustical Insulation above suspended ceilings.

1.3 SUBMITTALS

A. Product Data: Provide data on product characteristics, performance criteria, and product limitations.

B. Manufacturer's Installation Instructions: Include information on special environmental conditions required for installation and installation techniques.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

B. Provide the following upon request:
   1. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each product.
   2. Manufacturer's Certificate: Certify that products meet or exceed specified requirements, and that products contain no asbestos.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Project site in their original containers or packages or bundles bearing label clearly identifying manufacturer's name, brand, grade, UL listing, and other pertinent information.

B. Protect insulation materials from physical damage and from deterioration due to moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer’s written instructions for handling, storing, and protecting during installation.
1.6 FIELD CONDITIONS

A. Do not install insulation adhesives when temperature or weather conditions are detrimental to successful installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

2.2 ACOUSTICAL INSULATION MATERIALS

A. Batt Insulation - Walls: ASTM C 665, Type I; preformed batt; friction fit, for interior walls, conforming to the following:
   1. Material: Inorganic Glass Fiber with acrylic resin binder or Mineral Wool
   2. Flame Spread Index: 25 or less, when tested in accordance with ASTM E 84.
   3. Smoke Developed Index: 450 or less, when tested in accordance with ASTM E 84.
   4. Acoustical Performance: 3.5 inches
      a. NRC: 1.05
      b. STC: 49 minimum, installed in 3-5/8 metal stud wall with 5/8 inch gypsum board on each side.
   5. Facing: Unfaced.
   6. Manufacturers:
      c. Knauf Insulation; QuietTherm QT: www.knaufinsulation.us.
      d. Owens Corning Corp; QuietZone Acoustic Batts: www.owenscorning.com
      e. Thermafiber SAFB: www.thermafiber.com

B. Batt Insulation - Ceilings: ASTM C 665, Type I; preformed batt; above lay-in suspended ceilings, conforming to the following:
   1. Material: Inorganic Glass Fiber or Mineral Wool
   2. Flame Spread Index: 25 or less, when tested in accordance with ASTM E 84.
   3. Smoke Developed Index: 450 or less, when tested in accordance with ASTM E 84.
   4. Thickness: 2 and 3.5 inches, as indicated.
   5. Size: 24 inches by 48 inches
   7. Manufacturers:
      c. Knauf Insulation; QuietTherm QT: www.knaufinsulation.us.
      d. Owens Corning Corp; Sonobatts: www.owenscorning.com
      e. Thermafiber SAFB: www.thermafiber.com

C. Sustainability Requirements: Provide glass-fiber blanket insulation as follows:
   1. Free of Formaldehyde: Insulation manufactured with 100 percent acrylic binders and no formaldehyde.
2. Low Emitting: Insulation tested according to ASTM D 5116 and shown to emit less than 0.05-ppm formaldehyde.

2.3 ACCESSORIES

A. Insulation Fasteners: Impaling clip of galvanized steel with washer retainer and clips, to be mechanically fastened to surface to receive insulation, length to suit insulation thickness and substrate, capable of securely and rigidly fastening insulation in place.

B. Wire Mesh: Galvanized steel, hexagonal wire mesh.

C. Adhesives - General: Compatible with materials being adhered as instructed by insulation manufacturer for application; maximum VOC content of 50 g/L; GreenSeal GS-36 certified; in lieu of labeled product, independent test report showing compliance is acceptable.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that substrate, adjacent materials, and insulation materials are dry and that substrates are ready to receive insulation and adhesive.

B. Verify substrate surfaces are flat, free of honeycomb, fins, irregularities, or materials or substances that may impede adhesive bond.

3.2 BATT INSTALLATION

A. Install insulation in accordance with manufacturer's instructions.

B. Install in interior wall and furring spaces without gaps or voids. Do not compress insulation.

C. Trim insulation neatly to fit spaces. Insulate miscellaneous gaps and voids.

D. Fit insulation tightly in cavities and tightly to exterior side of mechanical and electrical services within the plane of the insulation. Insulation shall be tight within spaces in partitions, around cut openings, behind and around electrical and mechanical items within or behind partitions and tight to items passing through partitions.

E. Wall areas above ceiling: At side wall insulation in ceiling cavity, install adhesive-mounted impaling devices with metal caps at 24 inches vertically and at four (4) inches from each side of blankets horizontally. Install blankets with four (4) foot dimension running vertically on spikes, keeping blankets tight to exterior wall without crushing into each other.

F. Tape seal butt ends, lapped flanges, and tears or cuts in membrane.

3.3 INSTALLATION OF INSULATION IN CEILINGS FOR SOUND ATTENUATION

A. Where glass-fiber blankets are indicated for sound attenuation above ceilings separated by full-height partitions, install blanket insulation over entire ceiling area in thicknesses indicated. Extend insulation 48 inches up either side of partitions.
B. Where glass-fiber blankets are indicated for sound attenuation above suspended ceilings with partition below ceiling, fit insulation tightly above ceiling, loose laid. Refer to the suspended ceiling manufacturer's recommendations to ensure proper installation. Extend insulation 48 inches on both sides of partitions below.

3.4 PROTECTION

A. Protect installed insulation from damage due to physical abuse, and other causes. Provide temporary coverings or enclosures where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

END OF SECTION
SECTION 098433 - SOUND-ABSORBING WALL AND CEILING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes shop-fabricated, acoustical panel units tested for acoustical performance, including the following:
   1. Sound-absorbing wall panels.
   2. Acoustical board wall and ceiling panels.

1.3 DEFINITIONS
A. NRC: Noise Reduction Coefficient.

1.4 ACTION SUBMITTALS
A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal and Samples submittal. Ensure compliance with requirements included in Section 090413.
B. Product Data: For each type of product.
   1. Include panel edge, core material, and mounting indicated.
C. Sustainable Design Submittals required by Section 01813 applicable to this Section.
D. Shop Drawings: For unit assembly and installation.
   1. Include plans, elevations, sections, and mounting devices and details.
   2. Include details at panel head, base, joints, and corners; and details at ceiling, floor base, and wall intersections. Indicate panel edge profile and core materials.
   3. Include details at cutouts and penetrations for other work.
   4. Include direction of fabric weave and pattern matching.
E. Samples for Verification: For the following products:
   1. Assembled Panels: Approximately 36 by 36 inches, including joints and mounting methods.

1.5 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Elevations and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Electrical outlets, switches, and thermostats.
2. Items penetrating or covered by units including the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Alarms.
   e. Sprinklers.
   f. Access panels.
3. Show operation of hinged and sliding components covered by or adjacent to units.

1.6 CLOSEOUT SUBMITTALS
A. Maintenance Data: For each type of unit to include in maintenance manuals. Include fabric manufacturers' written cleaning and stain-removal instructions.

1.7 MAINTENANCE MATERIAL SUBMITTALS

1.8 QUALITY ASSURANCE
A. Provide the following upon request:
   1. Product Certificates: For each type of unit.

1.9 DELIVERY, STORAGE, AND HANDLING
A. Comply with fabric and unit manufacturers' written instructions for minimum and maximum temperature and humidity requirements for shipment, storage, and handling.
B. Deliver materials and units in unopened bundles and store in a temperature-controlled dry place with adequate air circulation.

1.10 FIELD CONDITIONS
A. Environmental Limitations: Do not install units until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, work at and above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.
B. Lighting: Do not install units until a lighting level of not less than 50 fc is provided on surfaces to receive the units.
C. Air-Quality Limitations: Protect units from exposure to airborne odors, such as tobacco smoke, and install units under conditions free from odor contamination of ambient air.
D. Field Measurements: Verify unit locations and actual dimensions of openings and penetrations by field measurements before fabrication, and indicate them on Shop Drawings.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: Units shall comply with "Surface-Burning Characteristics" or "Fire Growth Contribution" Subparagraph below, or both, as determined by testing identical products by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:

1. Surface-Burning Characteristics: Comply with ASTM E 84 or UL 723; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   a. Flame-Spread Index: 25 or less.
   b. Smoke-Developed Index: 450 or less.

2. Fire Growth Contribution: Comply with acceptance criteria of local code and authorities having jurisdiction when tested according to NFPA 265 Method B Protocol or NFPA 286.

2.2 SOUND-ABSORBING WALL UNITS

A. Acoustical Wall Panel: Manufacturer's standard panel construction consisting of fabric facing material stretched over front face of edge-framed core and bonded or attached to edges and back of frame.

1. Basis-of-Design Product: Subject to compliance with requirements, provide products by one of the following using fabric indicated on Drawings or comparable by Architect approved equal:
   a. Conwed Designscape; an Owens Corning company.
   b. Decoustics Limited; a Saint Gobain company.
   c. Golterman & Sabo.
   d. Snowsound.
   e. Topakustik.

2. Panel Shape: Flat.

3. Mounting: Back mounted with manufacturer's standard metal z-clips or bar hangers, secured to substrate.

4. Core: Manufacturer's standard Glass-fiber board or Mineral-fiber board.
   a. Core-Face Layer: Manufacturer's standard tackable, impact-resistant, high-density board.

5. Edge Construction: Manufacturer's standard chemically hardened core with no frame.

6. Edge Profile: Square.

7. Corner Detail in Elevation: Square with continuous edge profile indicated.

8. Facing Material: As indicated.

9. Acoustical Performance: Sound absorption NRC of not less than 0.80 according to ASTM C 423 for Type A mounting according to ASTM E 795.

10. Nominal Core Thickness: As indicated on Drawings.

11. Panel Width: As indicated on Drawings.

12. Panel Height: As indicated on Drawings.

B. Core Materials: Manufacturer's standard.

1. Glass-Fiber Board: ASTM C 612; of type standard with manufacturer; nominal density of 6 to 7 lb/cu. ft., unfaced, and dimensionally stable, molded rigid board; and with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively.
2. Mineral-Fiber Board: Maximum flame-spread and smoke-developed indexes of 25 and 10, respectively; minimum density of 13 lb/cu. ft., and with perforated surface.

3. Tackable, Impact-Resistant, High-Density Board for Face Layer: 1/8-inch thick layer of compressed molded glass-fiber board with a nominal density of 16 to 18 lb/cu. ft. laminated to face of core.

C. Fabric Facing Material: Fabric from same dye lot; color and pattern as selected by Architect from manufacturer's full range.

2.3 ACOUSTIC BOARD WALL AND CEILING PANELS

A. Sound-Absorbing Wall Panel Board: Manufacturer's standard panel construction consisting of black matte facing material laminated to black fiberglass core.

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by the following, or by Architect approved equal:
   a. Golterman & Sabo.
   b. Johns Manville.

2. Panel Shape: Flat.

3. Mounting:
   a. Wall: Back mounted with manufacturer's standard adhesive or hook and loop, secured to substrate.
   b. Ceiling: Direct mount as indicated.

4. Core: Manufacturer's standard Glass-fiber board.
5. Edge Construction: Manufacturer's standard.
6. Edge Profile: Square.
7. Corner Detail in Elevation: Square with continuous edge profile indicated.
8. Acoustical Performance: Sound absorption NRC of 0.90 according to ASTM C 423 for Type A mounting according to ASTM E 795.
9. Nominal Core Thickness: As indicated on Drawings.
10. Panel Width: As indicated on Drawings.
11. Panel Height: As indicated on Drawings.

2.4 ACCESSORY MATERIALS

A. Mounting Devices: Concealed on back of unit, recommended by manufacturer to support weight of unit, and as follows:

1. Adhesives: As recommended by unit manufacturer and with a VOC content of 70 g/L or less.
3. Metal Clips or Bar Hangers: Manufacturer's standard two-part metal "Z" clips, with one part of each clip mechanically attached to back of unit and the other part to substrate, designed to permit unit removal.

2.5 FABRICATION

A. Standard Construction: Use manufacturer's standard construction unless otherwise indicated; with facing material applied to face, edges, and back border of dimensionally stable core; and with rigid edges to reinforce panel perimeter against warpage and damage.
B. Edge Hardening: For glass-fiber board and mineral-fiber board cores, chemically harden core edges and areas of core where mounting devices are attached.

C. Core-Face Layer: Evenly stretched over core face and edges and securely attached to core; free from puckers, ripples, wrinkles, or sags.

D. Facing Material: Apply fabric facing fully covering visible surfaces of unit; with material stretched straight, on the grain, tight, square, and free from puckers, ripples, wrinkles, sags, blisters, seams, adhesive, or other visible distortions or foreign matter.
   2. Fabrics with Directional or Repeating Patterns or Directional Weave: Mark fabric top and attach fabric in same direction so pattern or weave matches in adjacent units.

E. Dimensional Tolerances of Finished Units: Plus or minus 1/16 inch for the following:
   1. Thickness.
   2. Edge straightness.
   3. Overall length and width.
   4. Squareness from corner to corner.
   5. Chords, radii, and diameters.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine fabric, fabricated units, substrates, areas, and conditions for compliance with requirements, installation tolerances, and other conditions affecting unit performance.

   B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
   A. Install units in locations indicated. Unless otherwise indicated, install units with vertical surfaces and edges plumb, top edges level and in alignment with other units, faces flush, and scribed to fit adjoining work accurately at borders and at penetrations.

   B. Comply with manufacturer's written instructions for installation of units using type of mounting devices indicated. Mount units securely to supporting substrate.

   C. Align fabric pattern and grain as directed by Architect.

3.3 INSTALLATION TOLERANCES
   A. Variation from Plumb and Level: Plus or minus 1/16 inch in 48 inches, noncumulative.

3.4 CLEANING
   A. Clip loose threads; remove pills and extraneous materials.
B. Clean panels on completion of installation to remove dust and other foreign materials according to manufacturer's written instructions.

END OF SECTION
SECTION 099113 - EXTERIOR PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary
   Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes surface preparation and the application of paint systems on exterior
   substrates.

B. Related Requirements:
   1. Section 055000 "Metal Fabrications" for shop priming metal fabrications.
   2. Section 055119 "Metal Grating Stairs" for shop priming metal grating stairs.
   3. Section 055213 "Pipe and Tube Railings" for shop priming pipe and tube railings.
   4. Section 099123 "Interior Painting" for paints used on interior surfaces.
   5. Section 099600 "High-Performance Coatings" for high-performance epoxy and
      polyurethane coatings.

1.3 DEFINITIONS

A. MPI Gloss Level 4 (Satin Finish): 20 to 35 units at 60 degrees and not less than
   35 units at 85 degrees, according to ASTM D 523.

B. MPI Gloss Level 5 (Semi-Gloss Finish): 35 to 70 units at 60 degrees, according to ASTM D 523.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include preparation requirements and application
   instructions.
   1. Include printout of current "MPI Approved Products List" for each product category
      specified, with the proposed product highlighted.
   2. Indicate VOC content.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Samples for Verification: For each type of paint system and each color and gloss of topcoat.
   1. Submit Samples on rigid backing, 8 inches square.
   2. Apply coats on Samples in steps to show each coat required for system.
   3. Label each coat of each Sample.
   4. Label each Sample for location and application area.

D. Product List: Cross-reference to paint system and locations of application areas. Use same
   designations indicated on Drawings and in schedules. Include color designations.
1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials[, from the same product run,] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Paint: 5 percent, but not less than 1 gal. of each material and color applied.

1.6 QUALITY ASSURANCE

A. Mockups: Apply mockups of each paint system indicated and each color and finish selected to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Architect will select one surface to represent surfaces and conditions for application of each paint system.
      a. Vertical and Horizontal Surfaces: Provide samples of at least 100 sq. ft..
      b. Other Items: Architect will designate items or areas required.
   2. Final approval of color selections will be based on mockups.
      a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.
   3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.
   1. Maintain containers in clean condition, free of foreign materials and residue.
   2. Remove rags and waste from storage areas daily.

1.8 FIELD CONDITIONS

A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F.

B. Do not apply paints in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Benjamin Moore & Co.
2.2 PAINT, GENERAL

A. Material Compatibility:
   1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
   2. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.

B. VOC Content: For field applications, paints and coatings shall comply with VOC content limits of authorities having jurisdiction.

C. Colors: As selected by Architect from manufacturer's full range.
   1. Ten percent of surface area will be painted with deep tones.

2.3 SOURCE QUALITY CONTROL

A. Testing of Paint Materials: District reserves the right to invoke the following procedure:
   1. District will engage the services of a qualified testing agency to sample paint materials. Contractor will be notified in advance and may be present when samples are taken. If paint materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
   2. Testing agency will perform tests for compliance with product requirements.
   3. District may direct Contractor to stop applying paints if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying paint materials from Project site, pay for testing, and repaint surfaces painted with rejected materials. Contractor will be required to remove rejected materials from previously painted surfaces if, on repainting with complying materials, the two paints are incompatible.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

2. Dunn-Edwards Corporation.
4. PPG Paints - PPG Architectural Coatings, Inc.
5. Sherwin-Williams Company (The).

B. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to products listed in the Exterior Painting Schedule for the paint category indicated.

C. Provide products indicated, or provide MPI-listed equivalent products from listed manufacturer's premium or professional product line.
B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
   1. Concrete: 12 percent.

C. Proceed with coating application only after unsatisfactory conditions have been corrected.
   1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates and paint systems indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
   1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection.

C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
   1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.

D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.

E. Steel Substrates: Remove rust, loose mill scale, and shop primer if any. Clean using methods recommended in writing by paint manufacturer.

F. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and areas where shop paint is abraded. Paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

G. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.

H. Aluminum Substrates: Remove loose surface oxidation.

I. Plastic Trim Fabrication Substrates: Remove dust, dirt, and other foreign material that might impair bond of paints to substrates.

3.3 APPLICATION

A. Apply paints according to manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual."
   1. Use applicators and techniques suited for paint and substrate indicated.
   2. Paint surfaces behind movable items same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed items with prime coat only.
3. Paint both sides and edges of exterior doors and entire exposed surface of exterior door frames.
4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.

B. Tint undercoats same color as topcoat, but tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

E. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:
1. Paint the following work where exposed to view:
   a. Equipment, including panelboards and switch gear, unless factory-applied finished.
   b. Uninsulated metal piping.
   c. Uninsulated plastic piping.
   d. Pipe hangers and supports.
   e. Metal conduit.
   f. Plastic conduit.
   g. Tanks that do not have factory-applied final finishes.

3.4 FIELD QUALITY CONTROL

A. Dry Film Thickness Testing: District may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.
   1. Contractor shall touch up and restore painted surfaces damaged by testing.
   2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.
D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.6 EXTERIOR PAINTING SCHEDULE

A. Concrete Substrates, Nontraffic Surfaces:
   1. Do not paint exposed formed architectural concrete, unless otherwise indicated.
   2. Latex System MPI EXT 3.1A:
      a. Prime Coat: Primer, alkali resistant, water based, MPI #3.
         1) Kelly-Moore 247 AcryShield 100-Percent Acrylic Exterior Masonry Primer
      c. Topcoat: Acrylic Latex, exterior, satin (MPI Gloss Level 4), MPI #15.
         1) Kelly-Moore 1247 AcryShield 100-Percent Acrylic Exterior Satin Enamel.

B. Steel and Iron Substrates:
   1. Water-Based Light Industrial Coating System MPI EXT 5.1C Modified:
         1) Kelly-Moore 5725 DTM Acrylic Metal Primer/Finish
      c. Topcoat: Light industrial coating, exterior, water based, semi-gloss (MPI Gloss Level 5), MPI #154.

C. Galvanized-Metal Substrates:
   1. Water-Based Light Industrial Coating System MPI EXT 5.3J Modified:
      a. Prime Coat: Primer, galvanized, water based, MPI #134.
         1) Kelly-Moore 5725 DTM Acrylic Metal Primer/Finish.
      c. Topcoat: Light industrial coating, exterior, water based, semi-gloss (MPI Gloss Level 5), MPI #154.

D. Aluminum Substrates:
   1. Water-Based Light Industrial Coating System MPI EXT 5.6G Modified:
      a. Prime Coat: Primer, quick dry, for aluminum, as recommended by topcoat manufacturer to suit conditions.
      c. Topcoat: Light industrial coating, exterior, water based, semi-gloss (MPI Gloss Level 5), MPI #154.

E. Stainless-Steel Substrates:
1. Prime Coat: Primer, quick dry, for aluminum, as recommended by topcoat manufacturer to suit conditions.
3. Topcoat: Light industrial coating, exterior, water based, semi-gloss (MPI Gloss Level 5), MPI #154.

F. Fiberglass Substrates:
1. Water-Based Light Industrial Coating System MPI EXT 6.8C Modified:
   a. Prime Coat: Primer, bonding, water based, MPI #17.
      1) Kelly-Moore 287 KEL-BOND Adhesion Plus
   c. Topcoat: Light industrial coating, exterior, water based, Semi-Gloss (MPI Gloss Level 5), MPI #11.
      1) 1250 AcryShield Exterior 100-Percent Acrylic Semi-Gloss Enamel

G. Plastic Trim Fabrication Substrates:
1. Water-Based Light Industrial Coating System MPI EXT 6.8C Modified:
   a. Prime Coat: Primer, bonding, water based, MPI #17.
      1) Kelly-Moore 287 KEL-BOND Adhesion Plus
   c. Topcoat: Light industrial coating, exterior, water based, Semi-Gloss (MPI Gloss Level 5), MPI #11.
      1) 1250 AcryShield Exterior 100-Percent Acrylic Semi-Gloss Enamel

END OF SECTION
SECTION 099123 - INTERIOR PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes surface preparation and the application of paint systems on the following interior substrates:
   1. Concrete.
   2. Steel and iron.
   3. Wood.
   4. Fiberglass.
   5. Plastic.
   7. Cotton or canvas insulation covering.
   8. ASJ insulation covering.

B. Related Requirements:
   1. Section 051200 "Structural Steel Framing" and Section 051213 "Architecturally Exposed Structural Steel Framing" for shop priming structural steel.
   2. Section 055000 "Metal Fabrications" for shop priming metal fabrications.
   3. Section 055113 "Metal Pan Stairs" for shop priming metal pan stairs.
   4. Section 055213 "Pipe and Tube Railings" for shop priming pipe and tube railings.
   5. for shop priming metal gratings.
   6. Section 099113 "Exterior Painting" for paints used on exterior surfaces.
   7. Section 099600 "High-Performance Coatings" for high-performance epoxy and polyurethane coatings.

1.3 DEFINITIONS

A. MPI Gloss Level 1 (Matte or Flat Finish): Not more than five units at 60 degrees and 10 units at 85 degrees, according to ASTM D 523.

B. MPI Gloss Level 3 (Eggshell Finish): 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.

C. MPI Gloss Level 5 (Semi-Gloss Finish): 35 to 70 units at 60 degrees, according to ASTM D 523.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include preparation requirements and application instructions.
   1. Include Printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.
2. Indicate VOC content.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Samples for Verification: For each type of paint system and in each color and gloss of topcoat.
   1. Submit Samples on rigid backing, 8 inches square.
   2. Apply coats on Samples in steps to show each coat required for system.
   3. Label each coat of each Sample.
   4. Label each Sample for location and application area.

D. Product List: Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules. Include color designations.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Paint: 5 percent, but not less than 1 gal. of each material and color applied.

1.6 QUALITY ASSURANCE

A. Mockups: Apply mockups of each paint system indicated and each color and finish selected to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Architect will select one surface to represent surfaces and conditions for application of each paint system.
      a. Vertical and Horizontal Surfaces: Provide samples of at least 100 sq. ft..
      b. Other Items: Architect will designate items or areas required.
   2. Final approval of color selections will be based on mockups.
      a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.
   3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.
   1. Maintain containers in clean condition, free of foreign materials and residue.
   2. Remove rags and waste from storage areas daily.

1.8 FIELD CONDITIONS

A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F.
B. Do not apply paints when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Benjamin Moore & Co.
2. Dunn-Edwards Corporation.
4. PPG Paints - PPG Architectural Coatings, Inc.
5. Sherwin-Williams Company (The).

B. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to products listed in the Exterior Painting Schedule for the paint category indicated.

C. Provide products indicated, or provide MPI-listed equivalent products from listed manufacturer's premium or professional product line.

2.2 PAINT, GENERAL

A. Material Compatibility:

1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.

B. VOC Content: For field applications that are inside the weatherproofing system, paints and coatings shall comply with South Coast Air Quality Management District (SCAQMD), Rule 1113, effective 07/01/2008:

1. Flat Paints, Coatings, and Primers: 50 g/L.
2. Nonflat Paints, Coatings, and Primers: 50 g/L.
3. Nonflat (High Gloss) Paints, Coatings, and Primers: 50 g/L.
4. Primers, Sealers, and Undercoaters: 100 g/L.
5. Anticorrosive and Anti-Rust Paints Applied to Ferrous Metals: 100 g/L.
6. Clear Wood Finishes, Lacquers: 275 g/L.
7. Clear Wood Finishes, Varnishes: 275 g/L.
8. Dry-Fog Coatings: 150 g/L.
9. Floor Coatings: 50 g/L.
10. High Temperature Industrial Maintenance Coatings: 420 g/L.
11. Industrial Maintenance Coatings: 100 g/L.
12. Pretreatment Wash Primers: 420 g/L.
13. Shellacs, Clear: 730 g/L.
14. Shellacs, Pigmented: 550 g/L.
15. Zinc-Rich Industrial Maintenance Primers: 100 g/L.
C. Low-Emitting Materials: For field applications that are inside the weatherproofing system, 90 percent of paints and coatings shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

D. Colors: As indicated in the finish schedule on the Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
   1. Concrete: 12 percent.
   2. Wood: 15 percent.
   3. Gypsum Board: 12 percent.

C. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.

D. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.

E. Proceed with coating application only after unsatisfactory conditions have been corrected.
   1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates and paint systems indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
   1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.

C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
   1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.

D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.

E. Steel Substrates: Remove rust, loose mill scale, and shop primer, if any. Clean using methods recommended in writing by paint manufacturer but not less than the following:
1. SSPC-SP 3.

F. Architecturally Exposed Steel Substrates: Remove rust, loose mill scale, and shop primer, if any. Clean using methods recommended in writing by paint manufacturer but not less than the following:
   1. SSPC-SP7/NACE No. 4.

G. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and areas where shop paint is abraded. Paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

H. Wood Substrates:
   1. Scrape and clean knots, and apply coat of knot sealer before applying primer.
   2. Sand surfaces that will be exposed to view, and dust off.
   3. Prime edges, ends, faces, undersides, and backsides of wood.
   4. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dried.

I. Cotton or Canvas Insulation Covering Substrates: Remove dust, dirt, and other foreign material that might impair bond of paints to substrates.

3.3 APPLICATION

A. Apply paints according to manufacturer's written instructions and to recommendations in "MPI Manual."
   1. Use applicators and techniques suited for paint and substrate indicated.
   2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
   3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
   4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
   5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.

B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Tint undercoats to match color of topcoat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

E. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:
   1. Paint the following work where exposed in equipment rooms:
      a. Equipment, including panelboards and switch gear, unless factory-applied finished.
      b. Uninsulated metal piping.
2. Paint the following work where exposed in occupied spaces:
   a. Equipment, including panelboards.
   b. Uninsulated metal piping.
   c. Uninsulated plastic piping.
   d. Pipe hangers and supports.
   e. Metal conduit.
   f. Plastic conduit.
   g. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
   h. Other items as directed by Architect.

3. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

3.4 FIRE-RATED AND SMOKE CONTAINMENT ASSEMBLIES

A. Fire walls, fire barriers, fire partitions, smoke barriers and smoke partitions or any other wall required to have protected openings or penetrations shall be effectively and permanently identified with signs or stenciling. Such identification shall:
   1. Be located in accessible concealed floor, floor-ceiling or attic spaces; and
   2. Be repeated at intervals not exceeding 30 feet measured horizontally along both sides of the wall or partition; and
   3. Include lettering not less than 0.5 inch in height, incorporating the suggested wording: "X HOUR FIRE AND/OR SMOKE BARRIER-PROTECT ALL OPENINGS" or other wording approved or required by AHJ (Authority Having Jurisdiction). Replace "X" with the appropriate designated hourly rating.
   4. Apply a minimum one-inch wide bright red horizontal line, both sides of wall, interrupted for approved text, at the required interval.

B. Refer to the Life Safety Plan Drawings for locations of walls and applicable ratings.

3.5 FIELD QUALITY CONTROL

A. Dry Film Thickness Testing: District may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.
   1. Contractor shall touch up and restore painted surfaces damaged by testing.
   2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.

3.6 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.7 INTERIOR PAINTING SCHEDULE

A. Concrete Substrates, Nontraffic Surfaces:
   1. Do not paint exposed formed architectural concrete, unless otherwise indicated.
   2. Institutional Low-Odor/VOC Latex System MPI INT 3.1M:
         1) Kelly-Moore AcryShield Interior Wall Primer Undercoat
      c. Topcoat: One of the following as directed by Architect:
         1) Latex, interior, institutional low odor/VOC Satin/Egg-shell (MPI Gloss Level 3), MPI #145.
            a) Kelly-Moore 1510 EnviroCoat 100% Acrylic Interior Eggshell Enamel
         2) Latex, interior, institutional low odor/VOC, semi-gloss (MPI Gloss Level 5), MPI #147.
            a) Kelly-Moore 1520 EnviroCoat 100% Acrylic Interior Semi-Gloss Enamel

B. Concrete Substrates, Traffic Surfaces, Architectural: Refer to Section 033546 a Sealed Concrete Finishing.

C. Concrete Substrates, Traffic Surfaces, Industrial/Maintenance: Refer to Section 071800 Traffic Coatings.

D. Steel Substrates:
   1. Institutional Low-Odor/VOC Latex System MPI INT 5.1S:
      a. Prime Coat: Primer, rust inhibitive, as recommended by finish coats manufacturer to suit conditions.
      c. Topcoat: Latex, interior, institutional low odor/VOC, semi-gloss (MPI Gloss Level 5), MPI #147 X-Green.
         1) Kelly-Moore 1500 EnviroCoat 100% Acrylic Interior Semigloss Enamel
   2. Water-Based Dry-Fall System MPI INT 5.1C:
      a. Prime Coat: Shop primer specified in Section where substrate is specified, or alkyd, quick dry, metal primer as recommended by topcoat manufacturer to suit conditions.
      b. Topcoat: Dry fall, latex, satin (MPI Gloss Level 3), MPI #155.
         1) Kelly-Moore 481 Dry Fog II Satin Latex Maintenance Finish.

E. Aluminum (Not Anodized or Otherwise Coated) Substrates:
   1. Institutional Low-Odor/VOC Latex System MPI INT 5.4G:
a. Prime Coat: Primer, quick dry, for aluminum as recommended by topcoat manufacturer to suit conditions.
c. Topcoat: Latex, interior, institutional low odor/VOC, semi-gloss (MPI Gloss Level 5), MPI #147 X-Green.
   1) Kelly-Moore 1500 EnviroCoat 100% Acrylic Interior Semigloss Enamel

   1. Institutional Low-Odor/VOC Latex System MPI INT 6.3V:
      a. Prime Coat: Primer, latex, for interior wood, MPI #39.
         1) Kelly-Moore 295 KEL-BOND Acrylic Universal Primer Intermediate Coat:
            Latex, interior, institutional low odor/VOC, matching topcoat.
      b. Topcoat: Latex, interior, institutional low odor/VOC, semi-gloss (MPI Gloss Level 5), MPI #147 X-Green.
         1) Kelly-Moore 1500 EnviroCoat 100% Acrylic Interior Semigloss Enamel

G. Fiberglass Substrates:
   1. Institutional Low-Odor/VOC Latex System MPI INT 6.7J:
      a. Prime Coat: Primer, bonding, water based, MPI #17.
         1) Kelly-Moore 287 KEL-BOND Adhesion Plus.
      c. Topcoat: Latex, interior, institutional low odor/VOC, semi-gloss (MPI Gloss Level 5), MPI #147 X-Green.
         1) Kelly-Moore 1500 EnviroCoat 100% Acrylic Interior Semigloss Enamel

H. Plastic Substrates:
   1. Institutional Low-Odor/VOC Latex System MPI INT 6.8F:
      a. Prime Coat: Primer, bonding, water based, MPI #17
         1) Kelly-Moore 287 KEL-BOND Adhesion Plus
      c. Topcoat: Latex, interior, institutional low odor/VOC, semi-gloss (MPI Gloss Level 5), MPI #147 X-Green.
         1) Kelly-Moore 1500 EnviroCoat 100% Acrylic Interior Semigloss Enamel
         2) 3)

I. Gypsum Board Substrates:
   1. Institutional Low-Odor/VOC Latex System MPI INT 9.2M:
      a. Prime Coat: Primer sealer, interior, institutional low odor/VOC, as recommended by topcoat manufacturer to suit conditions.
      c. Topcoat: One of the following as directed by Architect:
         1) Topcoat: Latex, interior, institutional low odor/VOC, flat (MPI Gloss Level 1), MPI #143 X-Green.
            a) Kelly-Moore 1500 EnviroCoat 100% Acrylic Interior Flat Enamel
2) Latex, interior, institutional low odor/VOC Satin/Egg-shell (MPI Gloss Level 3), MPI #145 X-Green.
   a) Kelly-Moore 1500 EnviroCoat 100% Acrylic Interior Eggshell Enamel
3) Latex, interior, institutional low odor/VOC, semi-gloss (MPI Gloss Level 5), MPI #147 X-Green.
   a) Kelly-Moore 1500 EnviroCoat 100% Acrylic Interior Semigloss Enamel

2. High-Performance Epoxy Coating: Refer to Section 099600 High-Performance Coatings.
3. Dry Erase Coating:
   a. Wall finish: Prepare to Level 5.
   b. Prime Base Coat: Magnetic primer, three coats at 5 wet mils per coat.
      1) IdeaPaint Magnetic Primer, White.
   c. Prime Coat: Primer sealer, latex, interior, as recommended by topcoat manufacturer to suit conditions; one coat.
   d. Topcoat: White, dry-erase topcoat, one coat at 5 mils per coat.
      1) IdeaPaint Create, White.

J. Cotton or Canvas and ASJ Insulation-Covering Substrates: Including pipe and duct coverings
1. Institutional Low-Odor/VOC Latex System MPI INT 10.1D:
   a. Prime Coat: Primer sealer, latex, interior, as recommended by topcoat manufacturer to suit conditions.
   c. Topcoat: Latex, interior, institutional low odor/VOC, low-sheen (MPI Gloss Level 2), MPI #144 X-Green
      1) Kelly-Moore 1500 EnviroCoat 100% Acrylic Interior Low Sheen Enamel.

END OF SECTION
SECTION 099600 - HIGH-PERFORMANCE COATINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes surface preparation and the application of high-performance coating systems on the following substrates:

1. Exterior Substrates:
   a. Steel.
   b. Galvanized metal.
   c. Non-ferrous metal.

2. Interior Substrates:
   a. Steel.
   b. Gypsum board.

B. Related Requirements:

1. Section 051200 "Structural Steel Framing" and Section 051213 "Architecturally Exposed Structural Steel Framing" for shop priming of structural steel with primers specified in this Section.

2. Section 055213 "Pipe and Tube Railings" for shop priming pipe and tube railings with coatings specified in this Section.

3. Section 099113 "Exterior Painting" for general exterior field painting.

4. Section 099123 "Interior Painting" for general interior field painting.

1.3 DEFINITIONS

A. MPI Gloss Level 5 (Semi-Gloss Finish): 35 to 70 units at 60 degrees, according to ASTM D 523.

B. MPI Gloss Level 6 (Gloss Finish): 70 to 85 units at 60 degrees, according to ASTM D 523.

C. MPI Gloss Level 7 (High-Gloss Finish): More than 85 units at 60 degrees, according to ASTM D 523.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include preparation requirements and application instructions.

1. Include printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.

2. Indicate VOC content.
B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Samples for Verification: For each type of coating system and each color and gloss of topcoat indicated.
   1. Submit Samples on rigid backing, 8 inches square.
   2. Apply coats on Samples in steps to show each coat required for system.
   3. Label each coat of each Sample.
   4. Label each Sample for location and application area.

D. Product List: Cross-reference to coating system and locations of application areas. Use same designations indicated on Drawings and in schedules. Include color designations.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials[, from the same product run,] that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Coatings: [5] <Insert number> percent, but not less than [1 gal.] <Insert number> of each material and color applied.

1.6 QUALITY ASSURANCE

A. Mockups: Apply mockups of each coating system indicated to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Architect will select one surface to represent surfaces and conditions for application of each coating system.
      a. Wall and Ceiling Surfaces: Provide samples of at least 100 sq. ft..
      b. Other Items: Architect will designate items or areas required.
   2. Final approval of color selections will be based on mockups.
      a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to District.
   3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.
   1. Maintain containers in clean condition, free of foreign materials and residue.
   2. Remove rags and waste from storage areas daily.
1.8 FIELD CONDITIONS

A. Apply coatings only when temperature of surfaces to be coated and ambient air temperatures are between 50 and 95 deg F.

B. Do not apply coatings when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

C. Do not apply exterior coatings in snow, rain, fog, or mist.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Benjamin Moore & Co.
   2. Carboline.
   3. Devoe Paint Company; Akzo Nobel.
   4. PPG Paints - PPG Architectural Coatings, Inc.
   5. Sherwin-Williams Company (The).
   6. Tnemec Company, Inc.

B. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to products listed in the Exterior High-Performance Coating Schedule or Interior High-Performance Coating Schedule for the coating category indicated.

C. Provide products indicated, or provide MPI-approved equivalent products from listed manufacturer's premium or professional product line.

2.2 HIGH-PERFORMANCE COATINGS, GENERAL

A. Material Compatibility:
   1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
   2. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.
   3. Products shall be of same manufacturer for each coat in a coating system.

B. VOC Content: For field applications that are inside the weatherproofing system, paints and coatings shall comply with VOC content limits of the South Coast Air Quality Management District (SCAQMD), Rule 1113, effective 07/01/2008 and the following VOC content limits:
   1. Flat Paints, Coatings, and Primers: VOC content of not more than 50 g/L.
   2. Nonflat Paints, Coatings, and Primers: VOC content of not more than 50 g/L.
   3. Nonflat (High Gloss) Paints, Coatings, and Primers: VOC content of not more than 50 g/L.
   4. Anticorrosive and Anti-Rust Paints Applied to Ferrous Metals: VOC content of not more than 100 g/L.
   5. Clear Wood Finishes, Varnishes: VOC not more than 275 g/L.
6. Clear Wood Finishes, Lacquers: VOC not more than 275 g/L.
7. Floor Coatings: VOC not more than 50 g/L.
8. Shellacs, Clear: VOC not more than 730 g/L.
9. Shellacs, Pigmented: VOC not more than 550 g/L.
10. Primers, Sealers, and Undercoaters: VOC content of not more than 100 g/L.

C. Low-Emitting Materials: For field applications that are inside the weatherproofing system, 90 percent of paints and coatings shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

D. Colors: As indicated in finish schedule on the Drawings.

2.3 SOURCE QUALITY CONTROL

A. Testing of Coating Materials: Owner reserves the right to invoke the following procedure:
1. Owner will engage the services of a qualified testing agency to sample coating materials. Contractor will be notified in advance and may be present when samples are taken. If coating materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
2. Testing agency will perform tests for compliance with product requirements.
3. Owner may direct Contractor to stop applying coatings if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying coating materials from Project site, pay for testing, and recoat surfaces coated with rejected materials. Contractor will be required to remove rejected materials from previously coated surfaces if, on recoating with complying materials, the two coatings are incompatible.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
   1. Gypsum Board: 12 percent.

C. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.

D. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.

E. Proceed with coating application only after unsatisfactory conditions have been corrected.
   1. Application of coating indicates acceptance of surfaces and conditions.
3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates and coating systems indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
   1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.

C. Clean substrates of substances that could impair bond of coatings, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
   1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce coating systems indicated.

D. Steel Substrates: Remove rust, loose mill scale, and shop primer if any. Clean using methods recommended in writing by paint manufacturer, but not less than SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning," except as follows:
   1. Items indicated as part of AESS Assembly: SSPC-SP 10/NACE No. 2, "Near-White Metal Blast Cleaning."

E. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and areas where shop paint is abraded. Paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

F. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied coatings.

3.3 APPLICATION

A. Apply high-performance coatings according to manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual."
   1. Use applicators and techniques suited for coating and substrate indicated.
   2. Coat surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, coat surfaces behind permanently fixed equipment or furniture with prime coat only.
   3. Coat backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
   4. Do not apply coatings over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.

B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of the same material are to be applied. Tint undercoats to match color of finish coat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through final coat, apply additional coats until cured film has a uniform coating finish, color, and appearance.
D. Apply coatings to produce surface films without cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections. Produce sharp glass lines and color breaks.

3.4 FIELD QUALITY CONTROL

A. Dry Film Thickness Testing: District may engage the services of a qualified testing and inspecting agency to inspect and test coatings for dry film thickness.

1. Contractor shall touch up and restore coated surfaces damaged by testing.
2. If test results show that dry film thickness of applied coating does not comply with coating manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with coating manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing coating application, clean spattered surfaces. Remove spattered coatings by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from coating operation. Correct damage to work of other trades by cleaning, repairing, replacing, and recoating, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced coated surfaces.

3.6 EXTERIOR HIGH-PERFORMANCE COATING SCHEDULE

A. Steel Substrates, Not shown to be Galvanized:

1. Refer to section 051200 - Structural Steel Framing for preparation, priming and for additional information regarding finishing of exterior exposed steel.
2. Pigmented Polyurethane over Epoxy Zinc-Rich Primer and High-Build Epoxy System MPI EXT 5.1G:
   a. Prime Coat: Primer, zinc rich, as recommended by finish coats manufacturer to suit conditions.
      1) AkzoNobel Devoe Bar-Rust 235 Multi-Purpose Epoxy Coating.
   c. First and Second Topcoat: Polyurethane, two component, pigmented, gloss (MPI Gloss Level 6).
      1) AkzoNobel Devoe Devthane 379 Aliphatic Urethane Gloss Enamel

B. Galvanized-Metal Substrates:

1. Refer to section 051200 - Structural Steel Framing for preparation, priming, and for additional information regarding finishing of exterior galvanized steel.
2. Avoid applying primers to chromate passivated galvanized steel, unless otherwise directed by manufacturer.
3. Pigmented Polyurethane over Epoxy Primer System:
   a. Prime Coat: Primer, epoxy, anti-corrosive, for metal, as recommended by finish coats manufacturer to suit conditions.
   c. Topcoat: Polyurethane, two component, pigmented, gloss (MPI Gloss Level 6), MPI #72.
      1) AkzoNobel Devoe Devthane 379 Aliphatic Urethane Gloss Enamel

C. Non-Ferrous Metal Substrates:
   1. Pigmented Polyurethane over Vinyl Wash and Epoxy Primer System MPI EXT 5.3D:
      a. Vinyl Wash: Vinyl butyral/phosphoric acid primer wash coat, as recommended by finish coats manufacturer to suit condition.
      b. Prime Coat: Primer, epoxy, anti-corrosive, for metal, as recommended by finish coats manufacturer to suit condition. Intermediate Coat: Polyurethane, two component, pigmented, gloss matching topcoat.
      c. Topcoat: Polyurethane, two component, pigmented, gloss (MPI Gloss Level 6), MPI #72.
         1) AkzoNobel Devoe Devthane 379 Aliphatic Urethane Gloss Enamel

3.7 INTERIOR HIGH-PERFORMANCE COATING SCHEDULE

A. Steel Substrates:
   1. Refer to Section 051213 for preparation for Architecturally Exposed Structural Steel Framing.
   2. Pigmented Polyurethane over High-Build Epoxy System:
      a. Application: Decorative AESS metal stairs, and all interior steel railings and handrails.
      b. Prime Coat: Primer, epoxy, anti-corrosive, for metal, as recommended by finish coats manufacturer to suit conditions.
      c. Intermediate Coat: Epoxy, high build.
         1) AkzoNobel Devoe Bar-Rust 235 Multi-Purpose Epoxy Coating.
      d. Topcoat: Polyurethane, two component, pigmented, gloss (MPI Gloss Level 6).
         1) AkzoNobel Devoe Devthane 379 Aliphatic Urethane Gloss Enamel

3. Epoxy, Waterborne Over Rust-Inhibitive Primer:
   a. Application: Hollow metal doors and frames, and other steel where indicated.
   b. Prime Coat: Primer, rust-inhibitive, as recommended by finish coats manufacturer to suit conditions.
   d. Topcoat: Waterborne epoxy, gloss (MPI Gloss Level 6).
      1) AkzoNobel Devoe Tru-Glaze-WB 4438

B. Gypsum Board Substrates, Abuse-Resistant, Epoxy-Like:
   1. Acrylic Enamel Over Latex Sealer:
         1) Kelly-Moore 971 AcryPlex Interior PVA Primer/Sealer

c. Topcoat: Water-based 100-Percent Acrylic, egg-shell (MPI Gloss Level 3).
   1) Kelly-Moore 1686 DuraPoxy 100% Acrylic Interior Eggshell Enamel

END OF SECTION
SECTION 100413 - COMMON SUBMITTAL REQUIREMENTS FOR SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows.
   Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
   1. Each submittal consists of items from only ONE Specifications section.
2. **Complete Submittal:** If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. **Partial Submittals:** If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

### C. Submittal Numbering

1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.

   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.

   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.

   c. **P-Number for Partial Submittals:** Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.

   d. **R-Number for Re-submittals:** Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.

   e. **Examples:**


### 3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. **Provide Submittal Review Sheet in PDF format.** Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:

   1. **Submittal Number:** See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

**END OF SECTION**
SECTION 101100 - VISUAL DISPLAY UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Porcelain-enamel markerboards.
   2. Glass markerboards.
   3. Sliding visual display assemblies.
   4. Interactive projection boards.

B. Related Requirements:
   1. Section 01030 "Alternates" for information affecting this Section.
   2. Section 092216 "Non-Structural Metal Framing" for sheet metal reinforcement in wall for mounting of visual display units.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, finishes, and accessories for visual display units.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For visual display units.
   1. Include plans, elevations, sections, details, wall reinforcement, and attachment to other work.
   2. Show locations of panel joints. Show locations of field-assembled joints for factory-fabricated units too large to ship in one piece.
   3. Include sections of typical trim members.

D. Samples for Verification: For each type of visual display unit indicated.
   1. Visual Display Panel: Not less than 8-1/2 by 11 inches, with facing, core, and backing indicated for final Work. Include one panel for each type, color, and texture required.
   2. Trim: 6-inch- long sections of each trim profile.
   3. Display Rail: 6-inch- long section of each type.
   4. Accessories: Full-size Sample of each type of accessory.

E. Product Schedule: For visual display units. Use same designations indicated on Drawings.
1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For visual display units[ and motorized units] to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Provide the following upon request:
   1. Qualification Data: For qualified Installer.
   2. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for surface-burning characteristics of tackboard materials.

C. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.
   1. Build mockup of each type of visual display unit as shown on Drawings. Include accessories.
   2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver factory-fabricated visual display units completely assembled in one piece. If dimensions exceed maximum manufactured unit size, or if unit size is impracticable to ship in one piece, provide two or more pieces with joints in locations indicated on approved Shop Drawings.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install visual display units until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, work above ceilings is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

B. Field Measurements: Verify actual dimensions of construction contiguous with visual display units by field measurements before fabrication.
   1. Allow for trimming and fitting where taking field measurements before fabrication might delay the Work.

1.8 WARRANTY

A. Special Warranty for Porcelain-Enamel Face Sheets: Manufacturer agrees to repair or replace porcelain-enamel face sheets that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
a. Surfaces lose original writing and erasing qualities.

b. Surfaces exhibit crazing, cracking, or flaking.

2. Warranty Period: 50 years from date of Substantial Completion.

B. Special Warranty for Interactive Projector Boards: Manufacturer agrees to repair or replace porcelain-enamel face sheets that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Surfaces lose original writing and erasing qualities.
   b. Surfaces exhibit crazing, cracking, or flaking.
   c. Flatness deviation greater than 2mm across face of board.

2. Warranty Period: 50 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain each type of visual display unit from single source from single manufacturer.

2.2 PORCELAIN-ENAMEL MARKERBOARDS (WHITE BOARDS)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Best-Rite Manufacturing; a brand division of MooreCo, Inc.
   2. Claridge Products and Equipment, Inc.

B. Visual Display Board Assembly: Field or factory fabricated.
   1. Assembly: Porcelain-enamel markerboard.
   2. Corners: Square.
   3. Width: As indicated on Drawings.
   4. Height: As indicated on Drawings.
   5. Mounting Method: Direct to wall.

C. Porcelain-Enamel Markerboard Panels: Balanced, high-pressure, factory-laminated markerboard assembly of three-ply construction, consisting of moisture-barrier backing, core material, and porcelain-enamel face sheet with low-gloss finish. Laminate panels under heat and pressure with manufacturer's standard, flexible waterproof adhesive.
   1. Face Sheet Thickness: 0.021 inch uncoated base metal thickness.
   2. Hardboard Core: 1/4 inch thick; with 0.005-inch- thick, aluminum foil backing.
   3. Laminating Adhesive: Manufacturer's standard moisture-resistant thermoplastic type.

D. Tackboard Panel: Natural-cork or Plastic-impregnated-cork tackboard panel on core indicated.
   1. Color and Pattern: As selected by Architect from full range of industry colors.
E. Aluminum Frames and Trim: Fabricated from not less than 0.062-inch-thick, extruded aluminum; standard size and shape.
   1. Field-Applied Trim: Manufacturer's standard, snap-on trim with no visible screws or exposed joints.

F. Mounting: Manufacturer's standard z-clip mounting system, or comparable as approved by Architect.

G. Markertray: Manufacturer's standard; continuous.
   1. Box Type: Extruded aluminum with slanted front, grooved tray, and cast-aluminum end closures.

H. Display Rail: Manufacturer's standard, extruded-aluminum display rail with insert, end stops, designed to hold accessories.
   1. Size: 2 inches high by full length of visual display unit.
   2. Map Hooks and Clips: Two map hooks with flexible metal clips for every 48 inches of display rail or fraction thereof.
   3. Tackboard Insert Color: As selected by Architect from full range of industry colors.

I. Paper Holder Display Rail: Extruded aluminum; designed to hold paper by clamping action.

2.3 GLASS MARKERBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Products by Clarus Glassboards, LLC., or comparable product by one of the following:
   1. Best-Rite Manufacturing; A brand division of MooreCo, Inc.
   2. Claridge Products and Equipment, Inc.

B. Glass Markerboards: 6-mm tempered glass markerboard, with smooth polished edge and eased corners; color coated on back surface.

C. Mounting: Round, stainless-steel standoffs, holding glass approximately 1 inch from wall surface; mounted through holes in markerboard.

D. Color and Surface: Matte white.

E. Markertray: Glass, supported by stainless-steel clips.

F. Size: As indicated.

2.4 SLIDING VISUAL DISPLAY UNITS

A. Alternates: Refer to Section 01030 "Alternates" for information effecting this Section.

B. Bottom-Supported, Horizontal-Sliding Visual Display Units: Factory-fabricated units consisting of extruded-aluminum tubular frame, fixed rear visual display panel, aluminum-framed horizontal-sliding visual display panels, and extruded-aluminum fascia that conceals overhead sliding track; designed for recessed mounting. Provide panels that operate smoothly without vibration or chatter.
1. Products: Subject to compliance with requirements, provide products as manufactured by one of the following:
   a. Best-Rite Manufacturing; A brand division of MooreCo, Inc.
   b. Claridge Products and Equipment, Inc.
   c. Platinum Visual Systems; a division of ABC School Equipment, Inc.

2. Panel Configuration: Provide panels in the following configurations as indicated:
   a. Two-Track Units: Fabricate unit with fixed rear panel covering entire rear surface. Provide two sliding panels, each equal size.

3. Top Track: One-piece track with integral fascia.

4. Bottom Track: One-piece bottom track with integral marker tray.

5. Hardware: Manufacturer's standard, extruded-aluminum overhead track and channel-shaped bottom guides; with minimum of two nylon ball-bearing carriers and two nylon rollers for each sliding panel (three carriers and rollers for panels over 96-inches long).

6. Overall Width: As indicated on Drawings.

7. Overall Height: As indicated on Drawings.

C. Panels and Accessories:
   1. Sliding Markerboard Panel: Porcelain-enamel-faced markerboard panel on 1/2-inch honeycomb core.
   2. Fixed Rear Markerboard Panel: Porcelain-enamel-faced markerboard panel on 1/2-inch honeycomb core.
   3. Backing Material: 0.015-inch thick, aluminum backing sheet.
   5. Aluminum Trim: Factory applied; in manufacturer's standard size and profile; with clear anodic finish.
   6. Mounting style: Wall mount and counter mount as indicated.

2.5 INTERACTIVE PROJECTION BOARDS

A. Description: Ultra-flat glass magnetic marker and projection board for use with interactive projector. Wall mounted and mobile units as indicated.

B. Basis-of-Design Product: Subject to compliance with requirements, provide Interactive Projector Boards as manufactured by MooreCo, Inc., or comparable by the following:

C. Characteristics:
   1. Size: 60 inch by 96 inch
   2. Trim: Clear anodized aluminum.
   3. Flatness: Not more than 2 mm across face of board.

D. Accessories: Include mounting brackets, fasteners, and accessories required for complete installation.
2.6 MATERIALS

A. Porcelain-Enamel Face Sheet: PEI-1002, with face sheet manufacturer’s standard two- or three-coat process.

B. Natural-Cork Sheet: Seamless, single-layer, compressed fine-grain cork sheet; bulletin board quality; face sanded for natural finish with surface-burning characteristics indicated.

C. Plastic-Impregnated-Cork Sheet: Seamless, homogeneous, self-sealing sheet consisting of granulated cork, linseed oil, resin binders, and dry pigments that are mixed and calendared onto fabric backing; with washable vinyl finish and integral color throughout with surface-burning characteristics indicated.

D. Hardboard: ANSI A135.4, tempered.

E. Clear Tempered Glass: ASTM C 1048, Kind FT, Condition A, Type I, Class 1, Quality Q3, with exposed edges seamed before tempering.

F. Extruded Aluminum: ASTM B 221, Alloy 6063.

G. Adhesives for Field Application: Mildew-resistant, nonstaining adhesive for use with specific type of panels, sheets, or assemblies; and for substrate application; as recommended in writing by visual display unit manufacturer.
   1. Adhesives shall have a VOC content of 50 g/L or less.

H. Primer/Sealer: Mildew-resistant primer/sealer complying with requirements in Section 099123 "Interior Painting" and recommended in writing by visual display unit manufacturer for intended substrate.

2.7 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM’s "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.8 ALUMINUM FINISHES

A. Finish after fabrication.

B. Clear Anodic Finish: AAMA 611, AA-M12C22A31, Class II, 0.010 mm or thicker.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances, surface conditions of wall, and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical power systems to verify actual locations of connections before installation of motorized, sliding visual display units.

C. Examine walls and partitions for proper preparation and reinforcement backing for visual display units.

D. Examine walls and partitions for suitable framing depth where sliding visual display units will be installed.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Comply with manufacturer's written instructions for surface preparation.

B. Clean substrates of substances, such as dirt, mold, and mildew, that could impair the performance of and affect the smooth, finished surfaces of visual display boards.

C. Prepare surfaces to achieve a smooth, dry, clean surface free of flaking, unsound coatings, cracks, defects, projections, depressions, and substances that will impair bond between visual display units and wall surfaces.

D. Prime wall surfaces indicated to receive visual display units and as recommended in writing by primer/sealer manufacturer and visual display unit manufacturer.

3.3 INSTALLATION

A. General: Install visual display surfaces according to manufacturer's written instructions in locations and at mounting heights indicated on Drawings, or if not indicated, at heights indicated below. Keep perimeter lines straight, level, and plumb. Provide grounds, clips, backing materials, adhesives, brackets, anchors, trim, and accessories necessary for complete installation.

B. Field-Assembled Visual Display Board Assemblies: Coordinate field-assembled units with grounds, trim, and accessories indicated. Join parts with a neat, precision fit.

1. Where size of visual display board assemblies or other conditions require support in addition to normal trim, provide structural supports or modify trim as indicated or as selected by Architect from manufacturer's standard structural support accessories to suit conditions indicated.

C. Factory-Fabricated Visual Display Board Assemblies: Attach concealed clips, brackets, hangers, and grounds to wall surfaces and to visual display board assemblies with fasteners at not more than 16 inches o.c. Secure tops and bottoms of boards to walls.
D. Visual Display Board Assembly Mounting Heights: Install visual display units at mounting heights indicated on Drawings, or if not indicated, at heights indicated below.
   1. Mounting Height: 36 inches above finished floor to top of markertray or bottom of board as applicable.

E. Sliding Visual Display Units: Install units at mounting heights indicated. Attach to wall framing with fasteners at not more than 16 inches o.c.
   1. Integrate with custom architectural casework as indicated.
   2. Adjust panels to operate smoothly without warp or bind. Lubricate operating hardware as recommended by manufacturer.

3.4 CLEANING AND PROTECTION

A. Clean visual display units according to manufacturer's written instructions. Attach one removable cleaning instructions label to visual display unit in each room.

B. Touch up factory-applied finishes to restore damaged or soiled areas.

C. Cover and protect visual display units after installation and cleaning.

D. Remove protective film prior to final inspection.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train District's maintenance personnel to adjust, operate, and maintain interactive visual display units.

END OF SECTION
SECTION 101200 - DISPLAY CASES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Display cases.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for display cases. Include furnished specialties and accessories.
   2. Include electrical characteristics for illuminated display cases.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For display cases.
   1. Include plans, elevations, sections, and attachment details.
   2. Show location of seams and joints in tackboard panels.
   3. Include sections of typical trim members.
   4. Include diagrams for wiring of illuminated display cases.

D. Samples: For each exposed product and for each color and texture specified; not less than 8-1/2 by 11 inches for tackboard panels and 6 inches long for trim with factory finish.

E. Samples for Initial Selection: For each type of exposed finish.
   1. Include Samples of tackboard panels and factory-finished trim involving color finish selection.

F. Samples for Verification: For each type of exposed finish for the following.
   1. Tackboard Panel: Not less than 8-1/2 by 11 inches, with facing and substrate indicated for final Work. Include one panel for each type, color, and texture required.
   2. Trim: 6-inch-long sections of each trim profile.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance Data: For display cases to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. Provide the following upon request:
   1. Product Test Reports: For tackboard panels, for tests performed by a qualified testing agency.
1.5 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install display cases for indoor installations until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, work above ceilings is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

B. Field Measurements: Verify actual dimensions of openings for display cases by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain display cases from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 450 or less.

B. Electrical Components: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 DISPLAY CASE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Best-Rite; MooreCo, Inc.
   2. Claridge Products and Equipment, Inc.
   3. Ghent Manufacturing, Inc.
   5. Poblocki Sign Company.

B. Recessed Display Case: Factory-fabricated display case; with finished interior, and glazed doors at front.
   1. Construction: Aluminum frame with glazed top, and side panels.
   2. Aluminum Finish: Clear anodized

C. Glazed Hinged Doors: Tempered glass; set in frame matching cabinet material and finish. Equip each door with full-height continuous hinge and cylinder lock with two keys.
   1. Thickness: Not less than 6 mm thick.
   2. Number of Doors: Two or Three depending on configuration.

D. Shelves: 6-mm-thick tempered glass; supported on adjustable shelf standards and supports.
   1. Shelf Depth: 8 inches.
2. Number of Shelves: Three.

E. Adjustable Shelf Standards and Supports: BHMA A156.9, B04071; with shelf rests, B04081; mounted on sides. Provide standards extending full height of display case.

F. Back Panel: Natural-cork tackboard panel.
   1. Color: As selected by Architect from manufacturer's full range.

G. Illumination System: Concealed top-lighting system consisting of fluorescent-strip fixtures. Include lamps and internal wiring with single concealed electrical connection to building system. Coordinate electrical characteristics with power supply provided.
   1. Ballasts: Low-temperature, high-power-factor, low-energy, fluorescent lamp ballasts that comply with Certified Ballast Manufacturers Association standards and carry its label.

H. Size: Width and configuration as indicated on Drawings by 60 inches high, by 8 inches deep.

2.4 TACKBOARD PANELS

A. Natural-Cork Tackboard Panel: 1/4-inch-thick, natural-cork sheet factory laminated to 1/4-inch-thick hardboard or particleboard backing.

2.5 MATERIALS

A. Hardboard: ANSI A135.4, tempered.

B. Fiberboard: ASTM C 208.

C. Particleboard: ANSI A208.1, Grade M-1, made with binder containing no urea formaldehyde.

D. Hardwood Plywood: HPVA HP-1, made with adhesive containing no urea formaldehyde.

E. Natural-Cork Sheet: Seamless, single-layer, compressed fine-grain cork sheet; bulletin board quality; face sanded for natural finish.

F. Extruded-Aluminum Bars and Shapes: ASTM B 221, Alloy 6063.

G. Aluminum Tubing: ASTM B 429/B 429M, Alloy 6063.

H. Clear Tempered Glass: ASTM C 1048, Kind FT, Condition A, Type I, Class 1, Quality Q3, with exposed edges seamed before tempering.

I. Fasteners: Provide screws, bolts, and other fastening devices made from same material as items being fastened, except provide hot-dip galvanized, stainless-steel, or aluminum fasteners for exterior applications. Provide types, sizes, and lengths to suit installation conditions. Use security fasteners where exposed to view.
2.6 FABRICATION

A. Fabricate display cases to requirements indicated for dimensions, design, and thickness and finish of materials. Configure end-to-end continuous cases as required to meet structural standards.

B. Use metals and shapes of thickness and reinforcing required to produce flat surfaces, and to impart strength for size, design, and application indicated.

C. Fabricate cabinets and door frames with reinforced corners, mitered to a hairline fit, with no exposed fasteners.

D. Fabricate shelf standards plumb and at heights to align shelf brackets for level shelves.

2.7 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.8 ALUMINUM FINISHES

A. Finish after fabrication.

B. Clear Anodic Finish: AAMA 611, AA-M12C22A31, Class II, 0.010 mm or thicker.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls, with Installer present, for compliance with requirements for installation tolerances, surface conditions of wall, and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical power systems to verify actual locations of connections before installation of illuminated units.

C. Examine walls and partitions for proper backing for display cases.

D. Examine walls and partitions for suitable framing depth if recessed units will be installed.

E. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 PREPARATION

A. Prepare recesses for display cases as required by type and size of unit.

3.3 INSTALLATION

A. General: Install units in locations and at mounting heights indicated on Drawings, or if not indicated, at heights indicated below. Keep perimeter lines straight, level, and plumb. Provide grounds, clips, backing materials, adhesives, brackets, anchors, trim, and accessories necessary for complete installation.

1. Mounting Height: 72 inches above finished floor to top of cabinet.

B. Recessed Display Cases: Attach units to wall framing with fasteners at not more than 16 inches (400 mm) o.c. Attach aluminum trim over edges of recessed display cases and conceal grounds and clips. Attach trim with fasteners at not more than 24 inches o.c.

C. Comply with requirements specified elsewhere for connecting illuminated display cases.

D. Install display case shelving level and straight.

3.4 ADJUSTING AND CLEANING

A. Adjust doors to operate smoothly without warp or bind and so contact points meet accurately. Lubricate operating hardware as recommended by manufacturer.

B. Cover and protect display cases after installation and cleaning.

C. Remove protective film prior to final inspection.

END OF SECTION
SECTION 101419 - DIMENSIONAL LETTER SIGNAGE

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. Cast dimensional characters.
      2. Cutout dimensional characters.
      3. Fabricated channel dimensional characters.
      4. Illuminated, fabricated channel dimensional characters.

1.2 DEFINITIONS
   A. Illuminated: Illuminated by lighting source integrally constructed as part of the sign unit.

1.3 COORDINATION
   A. Furnish templates for placement of electrical service embedded in permanent construction by other installers.

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product.
   B. Sustainable Design Submittals required by Section 01813 applicable to this Section.
   C. Shop Drawings: For signs.
      1. Include fabrication and installation details and attachments to other work.
      2. Show sign mounting heights, locations of supplementary supports to be provided by other installers, and accessories.
      3. Show message list, typestyles, graphic elements, and layout for each sign at least half size.
      4. Show locations of electrical service connections.
      5. Include diagrams for power, signal, and control wiring.
   D. Samples for Initial Selection: For each type of sign assembly, exposed component, and exposed finish.
      1. Include representative Samples of available typestyles and graphic symbols.
   E. Samples for Verification: For each type of sign assembly showing all components and with the required finish(es), in manufacturer's standard size unless otherwise indicated and as follows:
      1. Dimensional Characters: Half-size Sample of each type of dimensional character.
      2. Exposed Accessories: Full-size Sample of each accessory type.
      3. Full-size Samples, if approved, will be returned to Contractor for use in the Project.
   F. Product Schedule: For dimensional letter signs. Use same designations indicated on Drawings or specified.
G. Delegated-Design Submittal: For signs indicated in "Performance Requirements" Article.
   1. Include structural analysis calculations for signs indicated to comply with design loads; signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For signs to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer of products or An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Provide the following upon request:
   1. Qualification Data: For Installer.

1.7 FIELD CONDITIONS

A. Field Measurements: Verify locations of electrical service embedded in permanent construction by other installers by field measurements before fabrication, and indicate measurements on Shop Drawings.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of signs that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Deterioration of finishes beyond normal weathering.
      b. Separation or delamination of sheet materials and components.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design sign structure, mounting, and anchorage of dimensional character sign type(s) according to structural performance requirements.

B. Structural Performance: Signs and supporting elements shall withstand the effects of gravity and other loads within limits and under conditions indicated.
   1. Uniform Wind and Seismic Loads: As indicated on Drawings.
   2. Concentrated Horizontal Load: As indicated on Drawings.
   3. Other Design Load: As indicated on Drawings.
   4. Uniform and concentrated loads need not be assumed to act concurrently.
C. Thermal Movements: For exterior fabricated channel dimensional characters, allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 DIMENSIONAL CHARACTERS

A. Cast Characters: Characters with uniform faces, sharp corners, and precisely formed lines and profiles, and as follows:
   2. Material Thickness: Manufacturer's standard for size of character.
   3. Character Height: As indicated on Drawings.
   4. Finishes:
      a. Integral Aluminum Finish: Clear anodized.
   5. Mounting: Ceiling hung; manufacturer's standard for size and design of character.

B. Cutout Characters: Characters with uniform faces; square-cut, smooth, eased edges; precisely formed lines and profiles; and as follows:
   1. Character Material: Sheet or plate aluminum.
   2. Material Thickness: Manufacturer's standard for size of character.
   3. Character Height: As indicated on Drawings.
   4. Finishes:
      a. Integral Aluminum Finish: Clear anodized.
   5. Mounting: Ceiling hung; manufacturer's standard for size and design of character.

C. Fabricated Channel Characters: Metal face and side returns, formed free from warp and distortion; with uniform faces, sharp corners, and precisely formed lines and profiles; internally braced for stability, to meet structural performance loading without oil-canning or other surface deformation, and for securing fasteners; and as follows.
   1. Illuminated Characters: Backlighted character construction with LED lighting, including transformers, insulators, and other accessories for operability, with provision for servicing and concealing connections to building electrical system. Use tight or sealed joint construction to prevent unintentional light leakage. Space lamps apart from each other and away from character surfaces as needed to illuminate evenly.
      a. Power: As indicated on electrical Drawings.
      b. Weeps: Provide weep holes to drain water at lowest part of exterior characters. Equip weeps with permanent baffles to block light leakage without inhibiting drainage.
   2. Character Material: Sheet or plate aluminum.
   3. Material Thickness: Manufacturer's standard for size and design of character.
   4. Character Height: As indicated on Drawings.
   5. Character Depth: As indicated on Drawings.
   6. Finishes:
      a. Integral Aluminum Finish: Clear anodized.
   7. Mounting: Wall mounted; manufacturer's standard for size and design of character.
      a. Hold characters at manufacturer's recommended distance from wall surface.
2.3 DIMENSIONAL CHARACTER MATERIALS

A. Aluminum Castings: ASTM B 26/B 26M, alloy and temper recommended by sign manufacturer for casting process used and for type of use and finish indicated.

B. Aluminum Sheet and Plate: ASTM B 209, alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.

C. Aluminum Extrusions: ASTM B 221, alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.

D. Paints and Coatings for Sheet Materials: Inks, dyes, and paints that are recommended by manufacturer for optimum adherence to surface and are UV and water resistant for colors and exposure indicated.

2.4 ACCESSORIES

A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of signage, noncorrosive and compatible with each material joined, and complying with the following:
   1. Use concealed fasteners and anchors unless indicated to be exposed.

B. Exposed Metal-Fastener Components, General:
   1. Fabricated from same basic metal and finish of fastened metal unless otherwise indicated.
      a. Fastener Heads: For nonstructural connections, use flathead or oval countersunk screws and bolts with tamper-resistant Allen-head or one-way-head slots unless otherwise indicated.

C. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.5 FABRICATION

A. General: Provide manufacturer's standard sign assemblies according to requirements indicated.
   1. Preassemble signs and assemblies in the shop to greatest extent possible. Disassemble signs and assemblies only as necessary for shipping and handling limitations. Clearly mark units for reassembly and installation; apply markings in locations concealed from view after final assembly.
   2. Mill joints to a tight, hairline fit. Form assemblies and joints exposed to weather to resist water penetration and retention.
   3. Comply with AWS for recommended practices in welding and brazing. Provide welds and brazes behind finished surfaces without distorting or discoloring exposed side. Clean exposed welded and brazed connections of flux, and dress exposed and contact surfaces.
   4. Conceal connections if possible; otherwise, locate connections where they are inconspicuous.
   5. Internally brace signs for stability and for securing fasteners.
   6. Provide rebates, lugs, and brackets necessary to assemble components and to attach to existing work. Drill and tap for required fasteners. Use concealed fasteners where possible; use exposed fasteners that match sign finish.
7. Castings: Fabricate castings free of warp, cracks, blowholes, pits, scale, sand holes, and other defects that impair appearance or strength. Grind, wire brush, sandblast, and buff castings to remove seams, gate marks, casting flash, and other casting marks before finishing.

B. Brackets: Fabricate brackets, fittings, and hardware for bracket-mounted signs to suit sign construction and mounting conditions indicated. Modify manufacturer's standard brackets as required.

2.6 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

C. Organic, Anodic, and Chemically Produced Finishes: Apply to formed metal after fabrication but before applying contrasting polished finishes on raised features unless otherwise indicated.

2.7 ALUMINUM FINISHES

A. Clear Anodic Finish: AAMA 611, Class I, 0.018 mm or thicker.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Verify that sign-support surfaces are within tolerances to accommodate signs without gaps or irregularities between backs of signs and support surfaces unless otherwise indicated.

C. Verify that electrical service is correctly sized and located to accommodate signs.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install signs using mounting methods indicated and according to manufacturer's written instructions.

1. Install signs level, plumb, true to line, and at locations and heights indicated, with sign surfaces free of distortion and other defects in appearance.

2. Before installation, verify that sign surfaces are clean and free of materials or debris that would impair installation.

3. Corrosion Protection: Coat concealed surfaces of exterior aluminum in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.
B. Mounting Methods:
   1. Concealed Studs: Using a template, drill holes in substrate aligning with studs on back of sign. Remove loose debris from hole and substrate surface.
      a. Thin or Hollow Surfaces: Place sign in position and flush to surface, install washers and nuts on studs projecting through opposite side of surface, and tighten.
   2. Projecting Studs: Using a template, drill holes in substrate aligning with studs on back of sign. Remove loose debris from hole and substrate surface.
      a. Thin or Hollow Surfaces: Place spacers on studs, place sign in position with spacers pinched between sign and substrate, and install washers and nuts on stud ends projecting through opposite side of surface, and tighten.
   3. Through Fasteners: Drill holes in substrate using predrilled holes in sign as template. Countersink holes in sign if required. Place sign in position and flush to surface. Install through fasteners and tighten.
   4. Back Bar and Brackets: Remove loose debris from substrate surface and install backbar or bracket supports in position, so that signage is correctly located and aligned.

3.3 ADJUSTING AND CLEANING

A. Remove and replace damaged or deformed characters and signs that do not comply with specified requirements. Replace characters with damaged or deteriorated finishes or components that cannot be successfully repaired by finish touchup or similar minor repair procedures.

B. Remove temporary protective coverings and strippable films as signs are installed.

C. On completion of installation, clean exposed surfaces of signs according to manufacturer's written instructions, and touch up minor nicks and abrasions in finish. Maintain signs in a clean condition during construction and protect from damage until acceptance by Owner.
SECTION 101423 - SIGNAGE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. General signage requirements for the following:
      a. Accessibility signage
      b. Toilet room signage
      c. LEED-required signage.
      d. Emergency, directional, exit signage, and other code-related signage.

B. Related Requirements:
   1. Section 015000 "Temporary Facilities and Controls" for temporary Project identification signs and for temporary information and directional signs.
   2. Division 14 for "Elevator" Section for code-required conveying equipment signage.
   3. Division 22 Section for "Identification for Plumbing Piping and Equipment" for labels, tags, and nameplates for plumbing systems and equipment.
   4. Division 23 Section for "Identification for HVAC Piping and Equipment" for labels, tags, and nameplates for HVAC systems and equipment.
   5. Division 26 Section for "Identification for Electrical Systems" for labels, tags, and nameplates for electrical equipment.
   6. Division 26 Section for "Interior Lighting" for illuminated, self-luminous, and photoluminescent exit sign units.

1.3 DEFINITIONS

A. Accessible: In accordance with the accessibility standard.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For panel signs.
   1. Include fabrication and installation details and attachments to other work.
   2. Show sign mounting heights, locations of supplementary supports to be provided by others, and accessories.
   3. Show message list, typestyles, graphic elements, including raised characters and Braille, and layout for each sign at least half size.
D. Samples for Verification: For each type of sign assembly showing all components and with the required finish(es), in manufacturer's standard size unless otherwise indicated and as follows:
   1. Room-Identification Signs: Full-size Sample.
   2. Variable Component Materials: Full-size Sample of each base material, character (letter, number, and graphic element) in each exposed color and finish not included in Samples above.
   3. Exposed Accessories: Full-size Sample of each accessory type.

E. Sign Schedule: Use same designations specified or indicated on Drawings or in a sign schedule.

1.5 CLOSEOUT SUBMITTALS
   A. Maintenance Data: For signs to include in maintenance manuals.

1.6 QUALITY ASSURANCE
   A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.
   B. Provide the following upon request:
      1. Qualification Data: For Installer and manufacturer.

1.7 WARRANTY
   A. Special Warranty: Manufacturer agrees to repair or replace components of signs that fail in materials or workmanship within specified warranty period.
      1. Failures include, but are not limited to, the following:
         a. Deterioration of finishes beyond normal weathering.
         b. Deterioration of embedded graphic image.
         c. Separation or delamination of sheet materials and components.
      2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANEL SIGNS, GENERAL
   A. Regional Materials: Panel signs shall be manufactured within 100 miles of Project site.

2.2 PERFORMANCE REQUIREMENTS
   A. Accessibility Standard: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities and CBC Title 24 Chapter 11B for signs.
2.3 SIGNS

A. Room-Identification Signs, Wayfinding, and Emergency Signs: Sign with smooth, uniform surfaces; with message and characters having uniform faces, sharp corners, and precisely formed lines and profiles; and as follows:
   1. Basis-of-Design Product: Match District standards as provided by ASI Sign Systems, Inc.
   2. Mounting: Surface mounted to wall with two-face tape or hook-and-loop tape.
   3. Text and Typeface: Accessible raised characters and Braille. Finish raised characters to contrast with background color, and finish Braille to match background color.

B. Interior Corridor Super Graphics: Vinyl die cut letters, either self-adhered or adhesively applied. Images and text as indicated.

C. Entrance Signs, General:
   1. Building entrances that are accessible to and useable by physically handicapped persons shall be identified with at least one standard accessibility symbol sign and with additional directional signs as required, to be visible to persons along approaching pedestrian ways.
   2. Comply with CBC Section 11B-216.6.

D. Toilet Room Entry Signage:
   1. Provide geometric symbols as follows. Colors as selected.
   3. Women: 12-inch diameter circle with international symbol for women.
   4. Unisex: 12-inch diameter circle with 12-inch equilateral triangle.
   5. Comply with CBC Section 11B703.7.2.6, ADA Article 4.30.
   6. Provide sign with raised letters and Braille on the wall adjacent to the latch outside the door. Where there is no wall space on the latch side and at double leaf doors, provide sign on nearest adjacent wall. Comply with CBC Section 11B-703.4.2.
   7. Center symbols on door and signs on wall at a height of 60-inches above finished floor.

E. Emergency Exit at Elevator Signs:
   1. Sign Type: Panel with subsurface copy.
   2. Design: Pictorial sign of a standardized design indicating that in case of fire, the elevator will not operate and that exit stairways should be used.
   3. Provide one sign at each elevator lobby per floor. Mount sign directly above and centered on elevator call button plate.
   4. Comply with CBC Section 1007.10.

F. Tactile Stairwell Signs:
   1. Tactile floor design signs complying with CBC Section 1117B.5.1.1 shall be located at each floor level in enclosed stairways in buildings two or more stories in height to identify the floor level.
   2. Mount signs 60-inches above floor landing immediately adjacent to the door on the strike side unless otherwise approved by governing authorities.
   3. Signage shall comply with CBC Section 11B-705.

G. Stairway Floor Number Signs:
   1. Provide a minimum 18-inch x 12-inch sign at each floor landing in interior exit enclosures connecting more than three stories designating the floor level, the terminus of the top and bottom of the stair enclosure and the identification of the stair.
   2. Locate the sign 60-inches above the floor landing in a position that is readily visible when the doors are in the open and closed positions.
3. Comply with CBC Section 1022.9.

H. Area of Rescue Assistance Signage:

1. Each area of rescue assistance shall be identified by a sign which states "Area of Rescue Assistance" displaying the international symbol of accessibility. The sign shall be illuminated. Illumination levels shall be as required by ADA Appendix A40.30.8. Tactile signage complying with CBC Section 11B-703 shall be located at each door to an area of refuge. Comply with CBC Section 1007.6.5.

2. Provide a sign adjoining the two-way communication system with instructions on the use of the area under emergency conditions. Comply with CBC Section 1007.6.4.

I. Directional Signage:

1. Provide directional signage where indicated to clearly indicate the direction to areas of rescue assistance as required by ADA Article 4.3.11.5.

2. Signs shall comply with the general signage requirements of ADA Article 4.30.

J. Provide additional signs required by District and/or State of California and LEED requirements, including but not limited to the following:

1. "No Smoking Within 25 Feet of Main Entrances, Exits, Air Intakes and Operable Windows" mounted within 10 feet of opening at entrances and exits.

2. "No Smoking" on all entry doors mounted on the door. For glass, mount clear vinyl decal on inside of glass.

3. Provide signs with pictograph.

2.4 PANEL-SIGN MATERIALS

A. Aluminum Sheet and Plate: ASTM B 209, alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.

B. Aluminum Extrusions: ASTM B 221, alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.

C. Steel Materials:

1. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, G90 coating, either commercial or forming steel.

2. Steel Sheet: Uncoated, cold-rolled, ASTM A 1008/A 1008M, commercial steel, Type B, exposed.

3. Steel Members Fabricated from Plate or Bar Stock: ASTM A 529/A 529M or ASTM A 572/A 572M, 42,000-psi minimum yield strength.

4. For steel exposed to view on completion, provide materials having flat, smooth surfaces without blemishes. Do not use materials whose surfaces exhibit pitting, seam marks, roller marks, rolled trade names, or roughness.

D. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, Type 316, stretcher-leveled standard of flatness.

E. Acrylic Sheet: ASTM D 4802, category as standard with manufacturer for each sign, Type UVF (UV filtering).

F. Polycarbonate Sheet: ASTM C 1349, Appendix X1, Type II (coated, mar-resistant, UV-stabilized polycarbonate), with coating on both sides.
G. Fiberglass Sheet: Multiple laminations of glass-fiber-reinforced polyester resin with UV-light stable, colorfast, nonfading, weather- and stain-resistant, colored polyester gel coat, and with manufacturer's standard finish.

H. PVC Sheet: Manufacturer's standard, UV-light stable, PVC plastic.

I. Plastic-Laminate Sheet: NEMA LD 3, general-purpose HGS grade, 0.048-inch nominal thickness.

J. Vinyl Film: UV-resistant vinyl film of nominal thickness indicated, with pressure-sensitive, permanent adhesive on back; die cut to form characters or images as indicated.

K. Paints and Coatings for Sheet Materials: Inks, dyes, and paints that are recommended by manufacturer for optimum adherence to surface and are UV and water resistant for colors and exposure indicated.

2.5 ACCESSORIES

A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of signage, noncorrosive and compatible with each material joined, and complying with the following:
   1. For exterior exposure, furnish stainless-steel devices unless otherwise indicated.
   2. Exposed Metal-Fastener Components, General:
      a. Fabricated from same basic metal and finish of fastened metal unless otherwise indicated.
      b. Fastener Heads: For nonstructural connections, use screws and bolts with tamper-resistant spanner-head slots unless otherwise indicated.
   3. Sign Mounting Fasteners:
      a. Concealed Studs: Concealed (blind), threaded studs welded or brazed to back of sign material or screwed into back of sign assembly, unless otherwise indicated.
      b. Through Fasteners: Exposed metal fasteners matching sign finish, with type of head indicated, installed in predrilled holes.
   4. Inserts: Furnish inserts to be set by other trades into concrete or masonry work.

B. Adhesives: As recommended by sign manufacturer and with a VOC content of 70 g/L or less for adhesives used inside the weatherproofing system and applied on-site when calculated according to 40 CFR 59, Subpart D (EPA Method 24)

C. Two-Face Tape: Manufacturer's standard high-bond, foam-core tape, 0.045 inch thick, with adhesive on both sides.

D. Hook-and-Loop Tape: Manufacturer's standard two-part tape consisting of hooked part on sign back and looped side on mounting surface.

2.6 FABRICATION

A. General: Provide manufacturer's standard sign assemblies according to requirements indicated.
   1. Preassemble signs and assemblies in the shop to greatest extent possible. Disassemble signs and assemblies only as necessary for shipping and handling limitations. Clearly mark units for reassembly and installation; apply markings in locations concealed from view after final assembly.
B. Surface-Engraved Graphics: Machine engrave characters and other graphic devices into panel surface indicated to produce precisely formed copy, incised to uniform depth.
   1. Engraved Opaque Acrylic Sheet: Fill engraved graphics with manufacturer's standard enamel.
   2. Engraved Plastic Laminate: Engrave through exposed face ply of plastic-laminate sheet to expose contrasting core ply.

C. Subsurface-Applied Graphics: Apply graphics to back face of clear face-sheet material to produce precisely formed image. Image shall be free of rough edges.

D. Subsurface-Engraved Graphics: Reverse engrave back face of clear face-sheet material. Fill resulting copy with manufacturer's standard background color coating over enamel-filled copy.

E. Applied Vinyl: Align vinyl film in final position and apply to surface. Firmly press film from the middle outward to obtain good bond without blisters or fishmouths.

F. Brackets: Fabricate brackets, fittings, and hardware for bracket-mounted signs to suit sign construction and mounting conditions indicated. Modify manufacturer's standard brackets as required.
   1. Aluminum Brackets: Factory finish brackets with baked-enamel or powder-coat finish to match sign-background color color unless otherwise indicated.
   2. Stainless-Steel Brackets: Factory finish brackets with No. 4 finish unless otherwise indicated.

G. Signs with Changeable Message Capability: Fabricate signs to allow insertion of changeable messages as follows:
   1. For snap-in changeable inserts beneath removable face sheet, furnish one suction or other device to assist in removing face sheet. Furnish initial changeable insert. Subsequent changeable inserts are by . Furnish two blank inserts for each sign for District use.
   2. For slide-in changeable inserts, fabricate slot without burrs or constrictions that inhibit function. Furnish initial changeable insert. Furnish two blank inserts for each sign for District use.
   3. For frame to hold changeable sign panel, fabricate frame without burrs or constrictions that inhibit function. Furnish initial sign panel. Subsequent changeable sign panels are by District .

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of signage work.

B. Verify that sign-support surfaces are within tolerances to accommodate signs without gaps or irregularities between backs of signs and support surfaces unless otherwise indicated.

C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION

A. General: Install signs using mounting methods indicated and according to manufacturer's written instructions.
   1. Install signs level, plumb, true to line, and at locations and heights indicated, with sign surfaces free of distortion and other defects in appearance.
   2. Install signs so they do not protrude or obstruct according to the accessibility standard.
   3. Before installation, verify that sign surfaces are clean and free of materials or debris that would impair installation.

B. Room-Identification Signs and Other Accessible Signage: Install in locations on walls as indicated and according to accessibility standard.

C. Mounting Methods:
   1. Two-Face Tape: Clean bond-breaking materials from substrate surface and remove loose debris. Apply tape strips symmetrically to back of sign and of suitable quantity to support weight of sign without slippage. Keep strips away from edges to prevent visibility at sign edges. Place sign in position, and push to engage tape adhesive.
   2. Hook-and-Loop Tape: Clean bond-breaking materials from substrate surface and remove loose debris. Apply sign component of two-part tape strips symmetrically to back of sign and of suitable quantity to support weight of sign without slippage; push to engage tape adhesive. Keep tape strips 0.250 inch away from edges to prevent visibility at sign edges when sign is initially installed or reinstalled. Apply substrate component of tape to substrate in locations aligning with tape on back of sign; push and rub well to fully engage tape adhesive to substrate.
   3. Shim-Plate Mounting: Provide 1/8-inch thick, concealed aluminum shim plates with predrilled and countersunk holes, at locations indicated, and where other direct mounting methods are impractical. Attach plate with fasteners and anchors suitable for secure attachment to substrate. Attach signs to plate using <Insert mounting method> method specified above.

D. Signs Mounted on Glass: Provide opaque sheet matching sign material and finish onto opposite side of glass to conceal back of sign.

3.3 ADJUSTING AND CLEANING

A. Remove and replace damaged or deformed signs and signs that do not comply with specified requirements. Replace signs with damaged or deteriorated finishes or components that cannot be successfully repaired by finish touchup or similar minor repair procedures.

B. Remove temporary protective coverings and strippable films as signs are installed.

C. On completion of installation, clean exposed surfaces of signs according to manufacturer's written instructions, and touch up minor nicks and abrasions in finish. Maintain signs in a clean condition during construction and protect from damage until acceptance by District.

END OF SECTION
SECTION 102113.17 - PHENOLIC-CORE TOILET COMPARTMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Phenolic-core toilet compartments configured as toilet enclosures.

B. Related Requirements:
   1. Section 092216 "Non-Structural Metal Framing" for plate metal reinforcing in wall.
   2. Section 102800 "Toilet, Bath, and Laundry Accessories" for toilet tissue dispensers, grab bars, and similar accessories mounted on toilet compartments.

1.3 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal and Samples submittal. Ensure compliance with requirements included in Section 100413.

B. Product Data: For each type of product, unless otherwise indicated.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for toilet compartments.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Shop Drawings: For toilet compartments.
   1. Include plans, elevations, sections, details, and attachment details.
   2. Show locations of cutouts for compartment-mounted toilet accessories.
   3. Show locations of centerlines of toilet fixtures.
   4. Show locations of floor drains.
   5. Show ceiling grid, ceiling-mounted items, and overhead support or bracing locations.

E. Samples for Verification: For the following products, in manufacturer's standard sizes unless otherwise indicated:
   1. Each type of material, color, and finish required for toilet compartments, prepared on 6-inch-sq Samples of same thickness and material indicated for Work.
   2. Each type of hardware and accessory.

F. Product Schedule: For toilet compartments, prepared by or under the supervision of supplier, detailing location and selected colors for toilet compartment material.
1.4 INFORMATIONAL SUBMITTALS
   A. Product Certificates: For each type of toilet compartment.

1.5 CLOSEOUT SUBMITTALS
   A. Maintenance Data: For toilet compartments to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS
   A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Door Hinges: One set of hinge(s) with associated fasteners.
      2. Latch and Keeper: One latch(es) and keeper(s) with associated fasteners.
      3. Door Bumper: One door bumper(s) with associated fasteners.
      4. Door Pull: One door pull(s) with associated fasteners.

1.7 PROJECT CONDITIONS
   A. Field Measurements: Verify actual locations of toilet fixtures, walls, columns, ceilings, and other construction contiguous with toilet compartments by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
   A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
      1. Flame-Spread Index: 25 or less.
      2. Smoke-Developed Index: 450 or less.
   B. Recycled Content of Phenolic-Core Panel: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
   C. Regulatory Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities and CBC Title 24 for toilet compartments designated as accessible.

2.2 PHENOLIC-CORE TOILET COMPARTMENTS
   A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on the Drawings as manufactured by ASI Global Partitions, or comparable product by one of the following:
      1. Bobrick Toilet Partitions
      2. Bradley Corporation; Mills Partitions.
   B. Toilet-Enclosure Styles, as indicated:
1. TC-1: Floor anchored/Overhead braced.
2. TC-2: Ultimate privacy.

C. Door, Panel, and Pilaster Construction: Solid phenolic-core panel material with melamine facing on both sides fused to substrate during panel manufacture (not separately laminated), and with eased and polished edges, full height as indicated and no-sightline system. Provide minimum 3/4-inch- thick doors and pilasters and minimum 1/2-inch- thick panels.
   1. Heights: Standard heights as indicated, except as follows:
      a. Doors: From 1-inch above floor to 12-inches below ceiling.
      b. Panels between stalls: From 1-inch above floor to 1-inch below ceiling.
      c. Pilasters: From floor to ceiling.

D. Pilaster Shoes: Formed from stainless-steel sheet, not less than 0.031-inch nominal thickness and 3 inches high, finished to match hardware.

E. Brackets (Fittings):
   1. Full-Height (Continuous) Type: Manufacturer's standard design; stainless steel.

F. Phenolic-Panel Finish:
   1. Facing Sheet Finish: One or two colors and patterns in each room as indicated.
   2. Color and Pattern: As indicated by manufacturer's designations, with manufacturer's standard through-color core matching face sheet.
   3. Edge Color: Manufacturer's standard.

2.3 HARDWARE AND ACCESSORIES

A. Hardware and Accessories: Manufacturer's heavy-duty operating hardware and accessories.
   1. Hinges: Manufacturer's minimum 0.062-inch- thick stainless-steel paired, wrap-around, self-closing type that can be adjusted to hold doors open at any angle up to 90 degrees, allowing emergency access by lifting door. Mount with through-bolts.
   2. Latch and Keeper: Manufacturer's heavy-duty surface-mounted cast-stainless-steel, ADA-compliant sliding-type, lock/keeper latch unit designed to resist damage due to slamming, with combination rubber-faced door strike and keeper, and with provision for emergency access. Provide units that comply with regulatory requirements for accessibility at compartments designated as accessible. Mount with through-bolts.
   5. Door Pull: Manufacturer's heavy-duty cast-stainless-steel U-pull at out-swinging doors that complies with regulatory requirements for accessibility. Provide units on both sides of doors at compartments designated as accessible. Mount with through-bolts.

B. Anchorages and Fasteners: Manufacturer's standard exposed fasteners of stainless steel, finished to match the items they are securing, with theft-resistant-type heads. Provide sex-type bolts for through-bolt applications. For concealed anchors, use stainless-steel, hot-dip galvanized-steel, or other rust-resistant, protective-coated steel compatible with related materials.
2.4 MATERIALS
A. Stainless-Steel Sheet: ASTM A 666, Type 304, stretcher-leveled standard of flatness.
B. Stainless-Steel Castings: ASTM A 743/A 743M.

2.5 FABRICATION
A. Fabrication, General: Fabricate toilet compartment components to sizes indicated. Coordinate requirements and provide cutouts for through-partition toilet accessories where required for attachment of toilet accessories.
B. Overhead-Braced Units: Provide manufacturer's standard corrosion-resistant supports, leveling mechanism, and anchors at pilasters to suit floor conditions. Provide shoes at pilasters to conceal supports and leveling mechanism.
C. Door Size and Swings: Unless otherwise indicated, provide 24-inch wide in-swinging doors for standard toilet compartments and 36-inch wide out-swinging doors with a minimum 32-inch wide clear opening for compartments designated as accessible.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas and conditions, with Installer present, for compliance with requirements for fastening, support, alignment, operating clearances, and other conditions affecting performance of the Work.
   1. Confirm location and adequacy of blocking and supports required for installation.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. General: Comply with manufacturer's written installation instructions. Install units rigid, straight, level, and plumb. Secure units in position with manufacturer's recommended anchoring devices.
   1. Maximum Clearances:
      a. Pilasters and Panels: 1/2 inch.
      b. Panels and Walls: 1 inch.
   2. Full-Height (Continuous) Brackets: Secure panels to walls and to pilasters with full-height brackets.
      a. Locate bracket fasteners so holes for wall anchors occur in masonry or tile joints.
      b. Align brackets at pilasters with brackets at walls.
B. Overhead-Braced Units: Secure pilasters to floor and level, plumb, and tighten. Set pilasters with anchors penetrating not less than 1-3/4 inches into structural floor unless otherwise indicated in manufacturer's written instructions. Secure continuous head rail to each pilaster with no fewer than two fasteners. Hang doors to align tops of doors with tops of panels, and adjust so tops of doors are parallel with overhead brace when doors are in closed position.
3.3 ADJUSTING

A. Hardware Adjustment: Adjust and lubricate hardware according to hardware manufacturer's written instructions for proper operation. Set hinges on in-swinging doors to hold doors open approximately 30 degrees from closed position when unlatched. Set hinges on out-swinging doors to return doors to fully closed position.

END OF SECTION
SECTION 102600 - WALL AND DOOR PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

   A. Drawings and general provisions of the Contract, including General and Supplementary
      Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

   A. Section Includes:
      1. Wall guards.
      2. Corner guards.
      3. Impact-resistant wall coverings.

1.3 ACTION SUBMITTALS

   A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance
      Form may be submitted in lieu of required Product Data submittal and Samples submittal.
      Ensure compliance with requirements included in Section 100413.
   
   B. Product Data: Include construction details, material descriptions, impact strength,
      fire-test-response characteristics, dimensions of individual components and profiles, and
      finishes for each impact-resistant wall protection unit.
   
   C. Sustainable Design Submittals required by Section 01813 applicable to this Section.
   
   D. Shop Drawings: For each impact-resistant wall protection unit showing locations and extent.
      Include sections, details, and attachments to other work.
   
   E. Samples for Verification: For each type of exposed finish required, prepared on Samples of
      size indicated below.
      1. Wall and Corner Guards: 12 inches long. Include examples of joinery, corners, end
         caps, and field splices.
      2. Impact-Resistant Wall Covering: 6 by 6 inches square.

1.4 CLOSEOUT SUBMITTALS

   A. Maintenance Data: For each impact-resistant wall protection unit to include in maintenance
      manuals.
      1. Include recommended methods and frequency of maintenance for maintaining optimum
         condition of plastic covers under anticipated traffic and use conditions. Include
         precautions against using cleaning materials and methods that may be detrimental to
         plastic finishes and performance.
1.5 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer.

B. Source Limitations: Obtain impact-resistant wall protection units from single source from single manufacturer.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of impact-resistant wall protection units and are based on the specific system indicated. Refer to Section 014000 "Quality Requirements."

1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.

D. Surface-Burning Characteristics: Provide impact-resistant, plastic wall protection units with surface-burning characteristics as determined by testing identical products per ASTM E 84, NFPA 255, or UL 723 by UL or another qualified testing agency.

E. Regulatory Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and CBC Title 24 Chapter 11B.

F. Provide the following upon request:
   1. Qualification Data: For qualified Installer.
   2. Material Certificates: For each impact-resistant plastic material, from manufacturer.
   3. Material Test Reports: For each impact-resistant plastic material.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store impact-resistant wall protection units in original undamaged packages and containers inside well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.

1. Maintain room temperature within storage area at not less than 70 deg F during the period plastic materials are stored.

2. Keep plastic sheet material out of direct sunlight.

3. Store plastic wall protection components for a minimum of 72 hours, or until plastic material attains a minimum room temperature of 70 deg F.
   a. Store corner-guard covers in a vertical position.
   b. Store wall-guard covers in a horizontal position.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install impact-resistant wall protection units until building is enclosed and weatherproof, wet work is complete and dry, and HVAC system is operating and maintaining temperature at 70 deg F for not less than 72 hours before beginning installation and for the remainder of the construction period.
PART 2 - PRODUCTS

2.1 MATERIALS

A. PVC-Free Plastic: An engineered PETG that is free of PVC, phthalates, persistent bioaccumulative toxins (PBT) and bisphenol A (BPA) with UL® Class A/1 fire rating.

B. Aluminum Extrusions: Alloy and temper recommended by manufacturer for type of use and finish indicated, but with not less than strength and durability properties specified in ASTM B 221 for Alloy 6063-T5.

C. Stainless-Steel Sheet: ASTM A 240/A 240M.

D. Fasteners: Aluminum, nonmagnetic stainless-steel, or other noncorrosive metal screws, bolts, and other fasteners compatible with items being fastened. Use security-type fasteners where exposed to view.

E. Adhesive: As recommended by impact-resistant plastic wall protection manufacturer and with a VOC content of 70 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.2 WALL GUARDS

A. Chair Rail, Type CR-1: Heavy-duty assembly consisting of continuous snap-on plastic cover installed over concealed retainer system; designed to withstand impacts.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Model C800 as manufactured by Korogard Wall Protection Systems, or comparable product by the following:
   a. Construction Specialties, Inc
   b. IPC Door and Wall Protection Systems; Division of InPro Corporation.

2. Cover: Extruded rigid PVC-free plastic, minimum 0.100-inch wall thickness; as follows:
   a. Profile: Flat.
      1) Dimensions: Nominal 8 inches high by 1-1/4 inch deep.
      2) Surface: Uniform.
   b. Color and Texture: As indicated by manufacturer's designations.

3. Continuous Retainer: Minimum 0.080-inch thick, one-piece, extruded aluminum.


5. End Caps and Corners: Prefabricated, injection-molded plastic; matching color cover; field adjustable for close alignment with snap-on cover.

6. Mounting: Surface mounted directly to wall.

2.3 CORNER GUARDS

A. Surface-Mounted, Metal Corner Guards, Type CG-1: Fabricated from one-piece, formed or extruded metal with formed edges; with 90- or 135-degree turn to match wall condition.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Balco, Inc.
   b. Construction Specialties, Inc.
   c. IPC Door and Wall Protection Systems; Division of InPro Corporation.
   d. Korogard Wall Protection Systems; a division of RJF International Corporation.

2. Material: Stainless steel, Type 304.
   a. Thickness: Minimum 16-gauge.
   b. Finish: Directional satin, No. 4.

3. Wing Size: Nominal 3-1/2 by 3-1/2 inches.


5. Mounting: Double-faced, adhesive foam tape or Adhesive.

2.4 END-WALL GUARDS

A. Surface-Mounted, Metal, End-Wall Guards: Fabricated from one-piece, formed or extruded metal that covers entire end of wall; with formed edges.
   1. Manufacturers: Subject to compliance with requirements, match corner guards.
   2. Material: Stainless steel, Type 304.
      a. Thickness: Minimum 16-gauge.
      b. Finish: Directional satin, No. 4.


4. Mounting: Double-faced, adhesive foam tape or Adhesive.

2.5 IMPACT-RESISTANT WALL COVERINGS

A. Impact-Resistant Sheet Wall Covering: Fabricated from plastic sheet wall-covering material.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide PVC-free Acrovyn products by Construction Specialties, Inc., or comparable product by the following:
      a. IPC Door and Wall Protection Systems; Division of InPro Corporation.
   2. Sheet Thickness: 0.080 inch.
   3. Color and Texture: As selected by Architect from manufacturer's full range.
   4. Height: As indicated.
   5. Trim and Joint Moldings: Extruded rigid plastic that matches sheet wall covering color.

2.6 FABRICATION

A. Fabricate impact-resistant wall protection units to comply with requirements indicated for design, dimensions, and member sizes, including thicknesses of components.

B. Assemble components in factory to greatest extent possible to minimize field assembly. Disassemble only as necessary for shipping and handling.
C. Fabricate components with tight seams and joints with exposed edges rolled. Provide surfaces free of wrinkles, chips, dents, uneven coloration, and other imperfections. Fabricate members and fittings to produce flush, smooth, and rigid hairline joints.

2.7 METAL FINISHES

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Remove tool and die marks and stretch lines, or blend into finish.
   2. Grind and polish surfaces to produce uniform finish, free of cross scratches.
   3. Run grain of directional finishes with long dimension of each piece.
   4. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

B. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and wall areas, with Installer present, for compliance with requirements for installation tolerances, fire rating, and other conditions affecting performance of work.

B. Examine walls to which impact-resistant wall protection will be attached for blocking, grounds, and other solid backing that have been installed in the locations required for secure attachment of support fasteners.
   1. For impact-resistant wall protection units attached with adhesive or foam tape, verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Complete finishing operations, including painting, before installing impact-resistant wall protection system components.

B. Before installation, clean substrate to remove dust, debris, and loose particles.

3.3 INSTALLATION

A. General: Install impact-resistant wall protection units level, plumb, and true to line without distortions. Do not use materials with chips, cracks, voids, stains, or other defects that might be visible in the finished Work.
   1. Install impact-resistant wall protection units in locations and at mounting heights indicated on Drawings or, if not indicated, at heights indicated below:
      a. Crash Rails: Top at 40-inches above finished floor.
b. Corner and end-wall guards: Mount bottom above wall base to height indicated.
c. Hold back end caps of wall guards 1-inch from door frames where occurs.

2. Provide splices, mounting hardware, anchors, and other accessories required for a complete installation.
   a. Provide anchoring devices to withstand imposed loads.
   b. Where splices occur in horizontal runs of more than 20 feet, splice aluminum retainers and plastic covers at different locations along the run, but no closer than 12 inches.
   c. Adjust end caps as required to ensure tight seams.

B. Impact-Resistant Wall Covering: Install top and edge moldings, corners, and divider bars as required for a complete installation.

3.4 CLEANING

A. Immediately after completion of installation, clean plastic covers and accessories using a standard, ammonia-based, household cleaning agent.

B. Remove excess adhesive using methods and materials recommended in writing by manufacturer.

END OF SECTION
SECTION 102800 - TOILET, BATH AND MISCELLANEOUS ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section Includes:
      1. Public-use washroom accessories.
      2. Childcare accessories.
      3. Underlavatory guards.
      5. Miscellaneous accessories.
   B. Related Requirements:
      1. Section 088300 "Mirrors" for frameless mirrors.

1.3 COORDINATION
   A. Coordinate accessory locations with other work to prevent interference with clearances required for access by people with disabilities, and for proper installation, adjustment, operation, cleaning, and servicing of accessories.
   B. Coordinate accessory locations with in-wall reinforcing.

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product.
      1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
      2. Include anchoring and mounting requirements, including requirements for cutouts in other work and substrate preparation.
      3. Include electrical characteristics.
   B. Sustainable Design Submittals required by Section 01813 applicable to this Section.
   C. Samples: Full size, for each exposed product and for each finish specified.
      1. Approved full-size Samples will be returned and may be used in the Work.
   D. Product Schedule: Indicating types, quantities, sizes, and installation locations by room of each accessory required.
      1. Identify locations using room designations indicated.
      2. Identify accessories using designations indicated.
1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For accessories to include in maintenance manuals.

1.6 WARRANTY

A. Manufacturer's Special Warranty for Mirrors: Manufacturer agrees to repair or replace mirrors that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, visible silver spoilage defects.
   2. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OWNER-FURNISHED MATERIALS

A. Owner-Furnished, Contractor-Installed Materials: Soap dispenser, paper-towel dispenser.
   1. Soap Dispenser - GOJO Products; Model ADX-12 Dispenser; Grey
   2. Paper Towel Dispenser - Kimberly Clark; Model 09765 in-Sight Lev-r-Matic Roll Towel Dispenser; Smoke Grey

2.2 PUBLIC-USE WASHROOM ACCESSORIES

A. Source Limitations: Obtain public-use washroom accessories from single source from single manufacturer.

B. Standard Requirements: Standard finish for washroom accessories shall be brushed stainless steel, unless otherwise indicated. Provide keyed locks and standard mounting fasteners.

C. Basis-of-Design Product: Subject to compliance with requirements, provide listed product as manufactured by Bobrick Washroom Equipment, Inc., or comparable products by one of the following:
   1. A&J Washroom Accessories, Inc.

D. Toilet Tissue (Roll) Dispenser, Type TPD1:
      a. Description: Double-roll dispenser
      b. Mounting: Surface mounted, partition.
      c. Description: Double-roll dispenser

E. Combination Toilet Tissue Dispenser, Type TPD2:
      a. Description: Combination unit with double-roll toilet tissue dispenser and the following:
         1) Removable sanitary-napkin waste receptacle with self-closing, disposal-opening cover.
         2) Seat-cover dispenser with minimum capacity of 250 seat covers.
b. Mounting: Surface mounted, partition.

F. Combination Toilet Tissue Dispenser, Type TPD3:
      a. Description: Combination unit with double-roll toilet tissue dispenser and the following:
         1) Removable sanitary-napkin waste receptacle with self-closing, disposal-opening cover.
         2) Seat-cover dispenser with minimum capacity of 250 seat covers.
      b. Mounting: Partition mounted, dual access with two tissue rolls per compartment.

G. Grab Bar, Type GB1:
   1. Basis-of-Design Product: Bobrick B-6806-48
         b. Material: Stainless steel, 18-gauge, minimum.
            1) Finish: Smooth, No. 4 finish (satin).
      c. Outside Diameter: 1-1/2 inches.
      d. Configuration and Length: Straight, 48 inches long.

H. Grab Bar, Type GB2:
         b. Material: Stainless steel, 18-gauge, minimum.
            1) Finish: Smooth, No. 4 finish (satin).
      c. Outside Diameter: 1-1/2 inches.
      d. Configuration and Length: Straight, 36 inches long.

I. Sanitary-Napkin Disposal Unit, Type SND:
   1. Basis-of-Design Product: Bobrick B-270
      a. Mounting: Surface mounted.
         b. Cover: One-piece, seamless with continuous hinge.
         c. Receptacle: Removable

J. Seat-Cover Dispenser, Type SCD:
   1. Basis-of-Design Product: Bobrick B-221
      a. Mounting: Surface mounted.

K. Mirror Unit, Type M-1:
   1. Basis-of-Design Product: Bobrick B-165 1836
      a. Frame: Stainless-steel channel, 18-gauge.
         1) Corners: Welded and ground smooth.
         2) Finish: Bright polished.
1) One-piece, galvanized-steel, wall-hanger device.
2) Wall bracket of galvanized steel, equipped with concealed locking devices requiring a special tool to remove.

c. Size: 18 inches by 36 inches.

L. Coat Hook, Type CH:
   1. Basis-of-Design Product: B-212
      a. Description: Single-prong unit with rubber bumper.

M. Waste Receptacle, Type WR:
   1. Basis-of-Design Product: Bobrick B-3644
      a. Mounting: Open top, recessed.
      b. Minimum Capacity: 12 gallon (L).
      c. Liner: Reusable vinyl liner.

2.3 CHILDCARE ACCESSORIES

A. Source Limitations: Obtain childcare accessories from single source from single manufacturer.

B. Diaper-Changing Station, Type BCS: ASTM F 2285
   1. Basis-of-Design: Subject to compliance with requirements, provide Model KB110-SSRE as manufactured by Bobrick Washroom Equipment, Inc., or comparable by one of the following:
      b. Koala Kare Products.
   2. Description: Horizontal recessed unit that opens by folding down from stored position and with child-protection strap.
      a. Engineered to support minimum of 250-lb static load when opened.
   3. Mounting: Recessed mounted, flush wall with 4-inch recess depth.
   4. Operation: By pneumatic shock-absorbing mechanism, with continuous hinge.
   5. Material and Finish: 18-gauge, minimum, Type 304 stainless steel exterior with anti-microbial HDPE interior in manufacturer's standard color.

2.4 UNDERLAVATORY GUARDS

A. Underlavatory Guard:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Plumberex Specialty Products, Inc.
      b. Truebro by IPS Corporation.
   2. Description: Insulating pipe covering for supply and drain piping assemblies that prevents direct contact with and burns from piping; allow service access without removing coverings.
2.5 CUSTODIAL ACCESSORIES

A. Source Limitations: Obtain custodial accessories from single source from single manufacturer.

B. Basis-of-Design Product: Subject to compliance with requirements, provide listed product as manufactured by Bobrick Washroom Equipment, Inc., or comparable products by one of the following:
   1. A&J Washroom Accessories, Inc.

C. Mop and Broom Holder:
   1. Basis-of-Design Product: Bobrick B-239
      a. Description: Unit with shelf, hooks, holders, and rod suspended beneath shelf.
      b. Length: 34 inches.
      c. Hooks: Four.
      d. Mop/Broom Holders: Three, spring-loaded, rubber hat, cam type.

2.6 MISCELLANEOUS ACCESSORIES

A. Locate according to Drawings.

B. Products:
   2. AED device - ICE Safety Solutions; Philips HeartStart Onsite AED Model No. M5066A, with battery and wall mounted cabinet Model No. C1413F12.
   3. Evacuation Chair - Stryker Model No. 6254.

2.7 MATERIALS

A. Stainless Steel: ASTM A 666, Type 304, 18-gauge minimum nominal thickness unless otherwise indicated.

B. Galvanized-Steel Sheet: ASTM A 653/A 653M, with G60 hot-dip zinc coating.


D. Fasteners: Screws, bolts, and other devices of same material as accessory unit and tamper-and-theft resistant where exposed, and of galvanized steel where concealed.

E. Mirrors: ASTM C 1503, Mirror Glazing Quality, clear-glass mirrors, nominal 6.0 mm thick.

2.8 FABRICATION

A. General: Fabricate units with tight seams and joints, and exposed edges rolled. Hang doors and access panels with full-length, continuous hinges. Equip units for concealed anchorage and with corrosion-resistant backing plates.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Install accessories according to manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.

B. Grab Bars: Install to withstand a downward load of at least 250 lbf, when tested according to ASTM F 446.

3.2 ADJUSTING AND CLEANING

A. Adjust accessories for unencumbered, smooth operation. Replace damaged or defective items.

B. Remove temporary labels and protective coatings.

C. Clean and polish exposed surfaces according to manufacturer's written instructions.

END OF SECTION
SECTION 104413 - FIRE PROTECTION CABINETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Fire-protection cabinets for the following:
      a. Portable fire extinguishers.

B. Related Requirements:
   1. Section 104416 "Fire Extinguishers."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Show door hardware, cabinet type, trim style, and panel style. Include roughing-in dimensions and details showing recessed-, semirecessed-, or surface-mounting method and relationships of box and trim to surrounding construction.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For fire-protection cabinets. Include plans, elevations, sections, details, and attachments to other work.

D. Samples: For each type of exposed finish required.

E. Product Schedule: For fire-protection cabinets. Indicate whether recessed, semirecessed, or surface mounted. Coordinate final fire-protection cabinet schedule with fire-extinguisher schedule to ensure proper fit and function.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For fire-protection cabinets to include in maintenance manuals.

1.5 COORDINATION

A. Coordinate size of fire-protection cabinets to ensure that type and capacity of fire extinguishers indicated are accommodated.

B. Coordinate sizes and locations of fire-protection cabinets with wall depths.
1.6  SEQUENCING

A. Apply vinyl lettering on field-painted fire-protection cabinets after painting is complete.

PART 2 - PRODUCTS

2.1  PERFORMANCE REQUIREMENTS

A. Fire-Rated Fire-Protection Cabinets: Listed and labeled to comply with requirements in ASTM E 814 for fire-resistance rating of walls where they are installed.

2.2  FIRE-PROTECTION CABINET

A. Cabinet Type: Suitable for fire extinguisher.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. JL Industries, Inc.; a division of the Activar Construction Products Group.
   b. Larsens Manufacturing Company.
   c. Nystrom, Inc.
   d. Potter Roemer LLC.
   e. Strike First Corporation of America.

B. Cabinet Construction: Nonrated, and non-rated where occurs.

1. Fire-Rated Cabinets: Construct fire-rated cabinets with double walls fabricated from 0.043-inch thick cold-rolled steel sheet lined with minimum 5/8-inch thick fire-barrier material. Provide factory-drilled mounting holes. Provide fire rating to match wall construction in which cabinet is installed.

C. Cabinet Material: Cold-rolled steel sheet.

1. Shelf: Same metal and finish as cabinet.

D. Cabinet Size: Size to fit extinguisher indicated or as required by authorities having jurisdiction.

E. Semirecessed Cabinet: One-piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge (backbend).

1. Square-Edge Trim: 1-1/4- to 1-1/2-inch backbend depth.

F. Surface-Mounted Cabinet: Cabinet box fully exposed and mounted directly on wall with no trim.

G. Door Material: Steel sheet.

H. Door Style: Flush opaque panel, frameless, with no exposed hinges.

I. Door Hardware: Manufacturer's standard door-operating hardware of proper type for cabinet type, trim style, and door material and style indicated.

1. Provide recessed door pull and friction latch.
2. Provide concealed hinge permitting door to open 180 degrees.
3. Latch to operate with 5 lb maximum force per CBC Title 24 Chapter 11B.
J. Accessories:
1. Door Lock: Cam lock that allows door to be opened during emergency by pulling sharply on door handle.
2. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as directed by Architect.
   a. Identify fire extinguisher in fire-protection cabinet with the words "FIRE EXTINGUISHER."
      1) Location: Applied to cabinet door.
      2) Application Process: Pressure-sensitive vinyl letters.
      3) Lettering Color: Black.
      4) Orientation: Vertical.

K. Materials:
1. Cold-Rolled Steel: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B.
   b. Color: As selected by Architect from full range of industry colors and color densities.

2.3 GENERAL FINISH REQUIREMENTS
B. Protect mechanical finishes on exposed surfaces of fire-protection cabinets from damage by applying a strippable, temporary protective covering before shipping.
C. Finish fire-protection cabinets after assembly.
D. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine walls and partitions for suitable framing depth and blocking where recessed and semirecessed cabinets will be installed.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION
A. Prepare recesses for recessed and semirecessed fire-protection cabinets as required by type and size of cabinet and trim style.
3.3 INSTALLATION

A. General: Install fire-protection cabinets in locations and at mounting heights indicated or, if not indicated, at heights acceptable to authorities having jurisdiction.

B. Fire-Protection Cabinets: Fasten cabinets to structure, square and plumb.
   1. Unless otherwise indicated, provide recessed fire-protection cabinets. If wall thickness is inadequate for recessed cabinets, provide semirecessed fire-protection cabinets.
   2. Provide inside latch and lock for break-glass panels.
   3. Fasten mounting brackets to inside surface of fire-protection cabinets, square and plumb.
   4. Fire-Rated Cabinets:
      a. Install cabinet with not more than 1/16-inch tolerance between pipe OD and knockout OD. Center pipe within knockout.
      b. Seal through penetrations with firestopping sealant as specified in Section 078413 "Penetration Firestopping."

C. Identification: Apply vinyl lettering at locations indicated.

3.4 ADJUSTING AND CLEANING

A. Remove temporary protective coverings and strippable films, if any, as fire-protection cabinets are installed unless otherwise indicated in manufacturer's written installation instructions.

B. Adjust fire-protection cabinet doors to operate easily without binding. Verify that integral locking devices operate properly.

C. On completion of fire-protection cabinet installation, clean interior and exterior surfaces as recommended by manufacturer.

D. Touch up marred finishes, or replace fire-protection cabinets that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by fire-protection cabinet and mounting bracket manufacturers.

E. Replace fire-protection cabinets that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION
SECTION 104416 - FIRE EXTINGUISHERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes portable, hand-carried fire extinguishers and mounting brackets for fire extinguishers.

B. Related Requirements:

1. Section 104413 "Fire Protection Cabinets."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rating and classification, material descriptions, dimensions of individual components and profiles, and finishes for fire extinguisher.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Product Schedule: For fire extinguishers. Coordinate final fire-extinguisher schedule with fire-protection cabinet schedule to ensure proper fit and function.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire extinguishers to include in maintenance manuals.

1.5 COORDINATION

A. Coordinate type and capacity of fire extinguishers with fire-protection cabinets to ensure fit and function.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace fire extinguishers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Failure of hydrostatic test according to NFPA 10.

b. Faulty operation of valves or release levers.

2. Warranty Period: Six years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Portable Fire Extinguishers."

B. Fire Extinguishers: Listed and labeled for type, rating, and classification by an independent testing agency acceptable to authorities having jurisdiction.
   1. Provide fire extinguishers approved, listed, and labeled by FM Global.

2.2 PORTABLE, HAND-CARRIED FIRE EXTINGUISHERS

A. Fire Extinguishers: Type, size, and capacity for each fire-protection cabinet indicated.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Ansul Incorporated.
      b. Badger Fire Protection.
      c. JL Industries, Inc.; a division of the Activar Construction Products Group.
      d. Larsens Manufacturing Company.
      e. Nystrom Building Products.
      f. Potter Roemer LLC.
      g. Strike First Corporation of America.
   2. Valves: Manufacturer's standard.
   4. Instruction Labels: Include pictorial marking system complying with NFPA 10, Appendix B, and bar coding for documenting fire-extinguisher location, inspections, maintenance, and recharging.

B. Multipurpose Dry-Chemical Type in Brass Container: UL-rated 4-A:80-B:C, 10-lb nominal capacity, with monoammonium phosphate-based dry chemical in chrome-plated-brass container.

C. Clean-Agent Type in Aluminum Container <Insert drawing designation>: UL-rated 2-B:C, 2.5-lb nominal capacity, with HCFC Blend B agent and inert material in enameled-aluminum container; with pressure-indicating gage.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fire extinguishers for proper charging and tagging.
   1. Remove and replace damaged, defective, or undercharged fire extinguishers.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION

A. General: Install fire extinguishers and mounting brackets in locations indicated and in compliance with requirements of authorities having jurisdiction.

END OF SECTION
SECTION 110413 - COMMON SUBMITTAL REQUIREMENTS FOR EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER’S AND GENERAL CONTRACTOR’S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect’s staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:
   1. Action Codes Permitting Use:
      a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
      b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
      c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect’s notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
   1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering

1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 113100 - RESIDENTIAL APPLIANCES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Refrigerator/Freezer.
   2. Clothes Washer/Dryer.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include installation details, material descriptions, dimensions of individual components, and finishes for each appliance.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished accessories.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Samples: For each exposed product and for each color and texture specified, in manufacturer's standard size.

D. Product Schedule: For appliances. Use same designations indicated on Drawings.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each residential appliance to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Provide the following upon request:
   1. Qualification Data: For manufacturer.
   2. Product Certificates: For each type of appliance.
   3. Field quality-control reports.

1.6 WARRANTY

A. Special Warranties: Manufacturer agrees to repair or replace residential appliances or components that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

B. Refrigerator/Freezer, Sealed System: [Full warranty, including parts and labor,] [Limited warranty, including parts and labor for first year and parts thereafter,] for on-site service on the product.

1. Warranty Period for [Sealed Refrigeration System] <Insert item>: [Two] [Five] <Insert number> years from date of Substantial Completion.

2. Warranty Period [for Other Components] <Insert requirement>: [Two] <Insert number> years from date of Substantial Completion.

C. Clothes Washer: [Full warranty, including parts and labor,] [Limited warranty, including parts and labor for first year and parts thereafter,] <Insert description> for on-site service on the product.

1. Warranty Period: [Two] [Three] <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain residential appliances from single source and each type of residential appliance from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Electrical Appliances: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Accessibility: Where residential appliances are indicated to comply with accessibility requirements, comply with applicable provisions in the ABA standards of the Federal agency having jurisdiction and CBC Title 24 Chapter 11B.

2.3 REFRIGERATOR/FREEZERS

A. Refrigerator/Freezer: Two-door, side-by-side refrigerator/freezer and complying with AHAM HRF-1.

1. Basis-of-Design Product: Subject to compliance with requirements, provide GE Profile Model PSB48YSKSS 48" Built-In Side-by-Side Refrigerator with Dispenser, or comparable product by one of the following:
   a. LG Electronics.
   b. Maytag; a division of Whirlpool Corporation.
   c. Sub-Zero, Inc. (Sub-Zero and Wolf).
   d. Whirlpool Corporation.

2. Type: Built in.

3. Dimensions:
   a. Width: 48 inches.
   b. Depth: Approximately 28 inches.
   c. Height: 84 inches.
4. Storage Capacity: Total not less than 28 cu. ft.
5. General Features:
   a. Door Configuration: Flat door with hidden hinges.
   b. Dispenser in door for ice and cold water.
7. Front Panel(s): Stainless steel

2.4 CLOTHES WASHERS AND DRYERS
A. Clothes Washer/Dryer Combination: Complying with AHAM HLW-1.
   1. Basis-of-Design Product: Subject to compliance with requirements, provide GE Unitized Spacemaker Model GUD27ESPMGD 3.8 cu. ft. Capacity Washer with Stainless Steel Basket and 5.9 cu. ft. Capacity Electric Dryer, or comparable product by one of the following:
      a. LG Electronics.
      b. Maytag; a division of Whirlpool Corporation.
      c. Whirlpool Corporation.
   2. Type: Stacking, top-loading washer unit with front loading upper dryer.
   4. Controls:
      a. Wash Cycles: Not less than 10 wash cycles, including regular, delicate, and permanent press.
      b. Wash Temperatures: Not less than 4 settings.
      c. Wash/Rinse Temperatures: Not less than 6.
   5. Electrical Power: 120 V, 60 Hz, 1 phase, 15 A.
      a. Panel Color: Black or Dark Gray.

2.5 GENERAL FINISH REQUIREMENTS
A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, power connections, and other conditions affecting installation and performance of residential appliances.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before appliance installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install appliances according to manufacturer's written instructions.

B. Built-in Equipment: Securely anchor units to supporting cabinets or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and that rough openings are completely concealed.

C. District's maintenance personnel will service residential appliances.

END OF SECTION
SECTION 115310 - LABORATORY CASEWORK AND OTHER FURNISHINGS

PART 1 - GENERAL

1.1 SECTION INCLUDES
   A. Wood Laboratory Casework
   B. Metal Laboratory Casework and Tables
   C. Cabinet Hardware
   D. Laboratory Work Surfaces
   E. Electronics Bench
   F. Shelving Assemblies
   G. Modular Parts Bins
   H. Cylinder Rack and Restraint Assemblies
   I. Pipe Drop Enclosure
   J. Drying Rack
   K. Cable / Vacuum Line Through Port (Stainless Steel Benchtop Sleeve/Grommet)
   L. Plastic Grommets and Other Accessories
   M. Finish for Miscellaneous Wood Items
   N. Metal Fabrications
   O. Stainless Steel Fabrications
      1. Work Surfaces
      2. Laboratory Sinks and Cup Sinks
      3. Canopy Hoods
   P. Slotted Channel Framing (Strut)
   Q. Sealant

1.2 RELATED SECTIONS
   A. Division 01: Mockups
   B. Division 09: Flooring (wall base)
   C. Section 115313: Fume Hoods and Other Air Containment Units
D. Section 115343: Laboratory Service Fittings and Fixtures

E. Division 22: Plumbing

F. Division 23: Heating, Ventilated, and Air Conditioning (HVAC)

G. Division 26: Electrical

H. Division 27: Communications

1.3 REFERENCES


C. California Code of Regulations: Title 17, Section 93120: Airborne Toxic Control Measure to Reduce Formaldehyde Emissions from Composite Wood Products.


I. Scientific Equipment and Furniture Association: SEFA 8-M Recommended Practices for Laboratory Grade Metal Casework.

J. Underwriters Laboratory: UL61010A-1 Electrical Equipment for Laboratory Use.


1.4 BID SUBMITTALS

A. Certification of Compliance: All bidders (including those listed in 2.01-A) must submit a compliance certification statement indicating that their bid includes products and installation which comply with every requirement of the project specifications and drawings (accounting for any RFI responses received during the bidding phase).
B. Certification of Qualifications: All bidders must submit a certification of compliance with the Qualifications requirements outlined below. List specific project experience as evidence of compliance.

C. Substitution Requests: All substitution requests for this scope of work in this section must be made during the bidding phase. No substitution requests will be considered post-bid.

1.5 SUBMITTALS

A. Refer to General Conditions and Division 1 “Submittal Procedures” for submittal requirements. In addition to these requirements, provide submittal requirements specified herein.

B. Submittal requirements:

1. Submittal shall be prepared individually for this specification section. Arrange product data, drawings and information for submission in a complete set for this specification section.
   a. Shop drawings and product data as applicable for required mockups may be submitted separately and should be expedited for submittal as soon as the contract is awarded.

2. Submittal shall contain complete data for all items of this specification section. Periodic or partial submittals of individual components within this specification section will be returned as incomplete and rejected.

3. Submittals shall be organized by specification sequence with section and paragraph number identified.

4. Equipment and components being proposed shall be clearly labeled with all options and accessories indicated and shall be for this specific project. All non-applicable items shall be deleted or struck.

5. Product data submittals provided in PDF format shall consist of fully collated PDF files allowing for collated printing from a single file.

6. Shop drawings shall meet the requirements of the Architectural Woodworking Standards (AWS), except in cases where stricter requirements are identified in this section.

C. Materials List/Product Data: Submit complete materials list, including catalogue data, of all materials, equipment, and products for work in this section.

1. Product data shall not be duplicative or redundant with shop drawings. Do not include drawings in the product data submittal that are included in the shop drawings.

D. Shop Drawings: Submit complete shop fabrication and installation drawings, including plans, elevations, sections, details and schedules.

1. Show relationship to adjoining materials and construction.

2. Show seaming pattern layout of all joints in work surfaces.

3. Shop Drawings shall be in the form of reproducible, PDF files, or photocopies, to scale, sheet size not to exceed 11 inches by 17 inches (A3).

4. Shop drawing submittals provided in PDF format shall consist of fully collated files allowing for collated printing from a single file. Blueline prints are not acceptable.

E. Approved Substitution/Approved Equal: In addition to the items required in Division 1, all substitution requests shall include item-by-item comparison of the proposed substitution to this project specification. A copy of the project specification shall be submitted, with each item and subsection of the project specification marked as “Comply” or “Not Comply.” In any cases where
“Not Comply” is indicated, an explanation of the relative advantages of the proposed design shall be provided.

1. Substitution shall not affect dimensions shown on Drawings.
2. The Contractor shall pay for changes to the building design, including engineering design, detailing, utility and service requirements, and construction costs caused by the requested substitution.
3. Substitutions shall have no adverse effect on other trades, the construction schedule, or specified warranty requirements.
4. Maintenance and service parts shall be locally available for the proposed substitution.

F. LEED Submissions: Provide documentation and certification as required relative to the work of this section to support the project’s submission to the USGBC for the credits indicated below.

G. Submit detailed anchorage and attachment drawings and calculations provided by a licensed Structural Engineer complying with the Uniform Building Code Earthquake Regulations and the California Administrative Code, Title 24 Seismic Restraint requirements.

H. Samples: Accompanying Materials List, submit for Architect's approval two (2) samples of each type of specified finish and color range available for casework, laboratory work surfaces, painted steel fabrications, cabinet hardware, and shelving.

I. Certifications/ Test Data: Submit certifications and test data as required elsewhere in this section, including SEFA structural performance test reports, and finish performance test reports.

J. Operations/Maintenance Manuals: At project close-out, submit for Architect's review and Owner's use, complete operating and maintenance manuals that describe proper operating procedures, maintenance and replacement schedules, components parts list, and closest factory representative for components and service.
   1. Maintenance Materials: Furnish additional materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Furnish as follows:
      a. Provide 15% (Fifteen Percent) of total quantity of complete padlock hasp assemblies as additional spare parts, bagged, boxed, and clearly labeled.

K. Warranty: Submit manufacturer’s warranty including any additional certifications as needed to meet the requirements specified.

1.6 MOCKUP

A. Provide and install products within this scope of work as part of the laboratory mockup, as indicated on the drawings.

B. Location of mockup:
   1. In final location as shown on drawings. Note that products installed may require correction and/or replacement relative to issues of non-compliance with the contract documents.
   2. In off-site location in the vicinity of the project, provided by the Owner.
   3. At location provided by the laboratory subcontractor in the general vicinity of the project, such as a warehouse or shop, as approved by the Architect and Owner.

C. Disposition of mockup:
1. Mockup items may be incorporated into the final project subject to approval and/or corrections as identified in the mockup review.

2. Mockup items will remain the property of the laboratory subcontractor.

D. The mockup will be reviewed and appropriate comments documented. The mockup – and the associated comments - will become a quality sample against which the remainder of the product installation will be compared.

E. Coordinate delivery, installation, and review of the mockup with the contractor. The mockup should be complete and reviewed prior to fabrication of the remainder of the project. To the extent that the subcontractor elects to fabricate the project prior to review and approval of the mockup, it is understood that this is “at risk” and items may require re-fabrication to address issues that arise from the mockup review.

1.7 PRODUCT HANDLING

A. Protection: Use all means necessary to protect work of this section before, during and after installation including installed work and materials of other trades.

B. Replacement: Any damaged work shall be replaced, repaired and restored to original condition to the approval of the Architect at no additional cost or inconvenience to the Owner.

1.8 ENVIRONMENTAL CONDITIONS

A. It is the responsibility of the general contractor or construction manager to provide appropriate environmental conditions within the laboratory spaces throughout the period of installation of wood and composite wood casework products until substantial completion of the project and turnover to the owner. The relative humidity standards as delineated by the Architectural Woodwork Standards should be followed.

1. Humidity must be controlled between 25% and 55% in all areas where laboratory casework is stored and/or installed.

2. The range of relative humidity change should not exceed 30 percentage points.

B. It is the responsibility of the laboratory furniture subcontractor to assess building environmental conditions prior to the delivery and installation of laboratory casework. Wood laboratory casework shall not, under any circumstances, be installed in spaces which do not comply with the requirements outlined above.

1.9 QUALIFICATIONS

A. Work in this section shall be manufactured by and installed by a company/companies having a minimum of eight years documented experience providing and installing products similar to those specified in laboratory applications; an established organization; and production facilities including all tools, equipment and special machinery necessary for specializing in the fabrication and installation of the type of products specified, with skilled personnel, factory trained workmen and an experienced engineering department. Each shall have the demonstrated knowledge, ability and the proven capability to produce the specified work of the required quality and the proven capacity to complete an installation of this size and type within the required time limits.
1.10 ENVIRONMENTAL COMPLIANCE

A. Composite Wood Products – Composite wood products shall comply with the California Code of Regulations: Title 17, Section 93120: Airborne Toxic Control Measure to Reduce Formaldehyde Emissions from Composite Wood Products.

1. The definition of composite wood products, as applied to this requirement, shall be those as defined in the regulation cited.
2. Comply with the limitations scheduled for enforcement at the time of sale and manufacturing, accounting for the grace periods allowed by the regulation.
3. Provide documentation, certification, and labelling as required by the regulation.

B. Certified Wood: All wood products used in the fabrication shall comply with the FSC’s (Forest Stewardship Council’s) Principles and Criteria as required to contribute towards USGBC LEED MR Credit 7.

1. All lumber shall come from forestry sources that are certified under the Forestry Stewardship Council’s (FSC) Forest Management Certification program.
2. The casework manufacturer must have FSC Chain-of-Custody (COC) Certification.
3. Documentation:
   a. Provide manufacturer’s Chain of Custody Certification.
   b. Provide documentation of the cost, volume, and weight of all wood products provided for this project, including any non-FSC wood products or components.
   c. Provide documentation of the cost, volume, and weight of FSC wood products provided for this project.
   d. In the case of assemblies where some components are FSC-certified and other components are not – provide separate cost, volume, and weight information for each assembly component.

C. Low-Emitting Materials – Composite Wood and Agrifiber Products: Composite wood and agrifiber products used in casework products shall contain no added urea-formaldehyde resins, as required to meet USGBC LEED IEQ Credit 4.4.

1. Laminating adhesives used to fabricate on-site and shop-applied composite wood and agrifiber assemblies shall contain no added urea-formaldehyde resins.
2. Provide certification as required.

D. Wood products as listed below shall contain recycled content to contribute towards achievement of the USGBC LEED Green Building Rating System MR Credit 4.

1. Recycled wood products:
   a. Particleboard plywood cores.

2. The manufacturer shall submit documentation (i.e. “Source of Materials”, Invoices, Third Party Validation, etc.) for specified wood products purchased for this project providing recycled content.
   a. Where assemblies contain both recycled and non-recycled wood products, provide documentation of the weight of recycled wood products relative to the total weight of each assembly.
   b. Provide documentation of the cost of each component or assembly which contains recycled wood products. Provide percentages (by weight) and costs of post-consumer recycled material and pre-consumer recycled material within each component.
E. All steel used in the product fabrication shall comply with the recycled steel content requirements to contribute towards achievement of the USGBC LEED Green Building Rating System MR Credit 4.

1. All steel used in the fabrication of laboratory cabinets, fume hoods and modular laboratory systems shall have a minimum of 25% recycled steel content, as defined by ISO 14021-1999, calculated as follows:
2. (% of Post Consumer Recycled Steel Content by Weight) + 0.5 x (% of Pre-Consumer Recycled Content by Weight) >/= 20% (30%) (40%)
3. Documentation:
   a. The manufacturer shall submit documentation (i.e. “Source of Materials”, Invoices, Third Party Validation, etc.) for steel purchased for this project providing recycled content.
   b. Provide documentation of the cost of each component which contains recycled steel.
   c. Provide percentages (by weight) and costs of post-consumer recycled material and pre-consumer recycled material within each component.

1.11 WARRANTY

A. All products shall be warranted to be free from defects in materials and workmanship for a period of five years following substantial completion. The manufacturer/ dealer/ subcontractor shall repair or replace any products (or parts thereof) that are found to be defective. Replacement will include any parts, labor, shipping, and travel expenses involved. Warranty replacement work must be scheduled in coordination with the Owner’s academic/research schedule, and may therefore require evening and/or weekend work.

PART 2 - PRODUCTS

2.1 WOOD LABORATORY CASEWORK

A. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.
1. CiF Lab Solutions, 53 Courtland Avenue, Vaughan, Ontario, Canada L4K 3T2 Tel: 905 738-5821.
2. Kewaunee Scientific Corporation, P O Box 1842, Statesville, NC 28687 Tel: 704 873-7202.
3. Mott Manufacturing Ltd., 452 Hardy Road, P. O. Box 1120, Brantford, ON, Canada N3T 5T3 Tel: 519 752-7825.
4. Diversified Woodcrafts, Inc ., 300 South Krueger Street, Suring, WI 54174 Tel: 920 842-2136.
5. Pacific Cabinets Inc., 2010 Front Street, Ferdinand, Idaho 83526 Tel: 208 962-5546.
6. ICIscientific, 1865 Highway 641 North, Paris, TN 38242-8814 Tel: 731-642-4251.
7. Approved substitution.

B. Quality Standards:
1. Wood casework shall comply with all requirements of AWS Custom Grade architectural cabinets, unless otherwise specified in this section.
C. Design Requirements:

1. Door and drawer design: Square edged full flush overlay design with eased edges. Applied panels may be required in areas such as sink cabinets and knee spaces with pencil drawers to complete the flush construction. Reveals shall be within the ranges indicated below; however, they shall be consistent across a given project.
   
   a. Reveal from top of door/drawer fronts to top of cabinet: 3/32 inch to 3/8 inch.
   b. Reveal from bottom of door/drawer fronts to bottom of cabinet bottom panel: Flush.
   c. Horizontal and vertical reveals between door and drawer fronts: 3/32 inch to 3/16 inch.
   d. Vertical reveal between side of door and drawer fronts and the side of the cabinet: one-half of the typical horizontal and vertical reveal.

2. Pulls on doors shall be mounted vertically and on drawers horizontally.

3. Grain Pattern:
   
   a. Vertical Matched Grain Pattern: Grain pattern on all exposed surfaces shall be vertical. Entire cabinet front must be cut from a single panel.

4. Toe Kicks/Toe Spaces:
   
   a. All tall storage cabinets to have toe space to match base units.
   b. Provide toe spaces at all fully-exposed sides of cabinets, including locations such as the end of island benches, the end of peninsula benches, and outside-corner cabinets. Toe spaces shall run continuously through all items such as knee opening side panels and end panels.

5. Full-Flush Construction and Installation: All finished panels and surfaces shall be in the same plane as the front of cabinet doors/drawers to provide a true flush overlay appearance.
   
   a. Filler panels: Provide filler panels where casework units meet perpendicular walls to create a continuous appearance.
      
      1). Full-flush end-of-run filler panels are required at all conditions where the joint width is one inch or larger. At conditions where the joint width is less than one inch, filler panel should be flush with cabinet body.
   b. Flush panels: Provide fixed fully-edgebanded flush panels at sink cabinets, knee opening drawer units, filler panels, and elsewhere, so that all finished panels are in the same plane as cabinet doors and drawers to provide a true flush overlay appearance.
   c. Applied panels may be required in areas such as sink cabinets and knee spaces with pencil drawers to complete the flush construction.
   d. At outside corners, align side panel of cabinet with the face of the door of adjacent cabinet.
   e. At inside corners, mount filler panels flush with face of adjacent cabinet doors.
   f. At open cabinets (without doors), at knee opening side panels, and similar conditions, align face of cabinet with face of adjacent cabinet door. Adjust the depth of the cabinet and toe kick accordingly.
   g. Align other filler panels and applied panels with face of adjacent cabinet doors.
   h. Align face of end panels and knee-opening side panels with face of adjacent cabinet doors.
   i. Provide filler/trim panels at locations where undercounter dishwashers or glasswashers are shown and the units provided do not completely fill the opening indicated.
   j. Where knee openings are located against a wall, provide a side/end panel against the wall.
   k. Filler panels shall follow the profile of toe kicks.
6. Extended Ends:
   a. At end-of-run base cabinets, provide extended end to cabinet to create closure to the wall without the use of filler panels. Extended end shall be edgebanded on front and bottom edges. Back edge shall be scribed to the wall with a tight hairline joint. Field-applied panels do not meet this requirement.
   b. At ends of island benches and peninsula benches, provide a paired set of base cabinets, each with an extended end, resulting in a single joint. These extended end panels shall be edgebanded on the front and bottom edges and shall meet at a hairline joint. Applied panels do not meet this requirement.

7. Flush interiors: Set cupboard bottom flush with front-end facers. Surface mounted bottoms and offsets caused by front face frames that interfere with ease of cleaning are not acceptable.

8. Widths of drawer bodies in knee opening rails shall not be less than 18 inches (457 mm). As noted above, applied panel shall be provided to complete the flush construction on either side of the drawer head.

D. Materials and Finishes:

1. Wood:
   a. Definition of cabinet components by surface visibility:
      1). Exposed Surfaces:
         a). Surfaces exposed when doors and drawers are closed.
         b). Surfaces visible when behind glass doors, including tops and bottoms of shelves.
         c). All exterior surfaces of suspended casework.
         d). Open units.
         e). Bottoms of cabinets if 42 inches (1070 mm) or more above finished floor.
         f). Tops of cabinets if less than 72 inches (1830 mm) above finished floor.
         g). Front rail of web frames.
      2). Semi-exposed surfaces:
         a). Surfaces that are visible when solid (opaque) doors are open or drawers are extended, including backs of doors.
         b). Tops of cabinets 72 inches (1830 mm) or more above finished floor when visible from an upper level.
      3). Unexposed surfaces:
         a). Surfaces not normally visible after installation with doors open and drawers extended.
         b). Bottoms of cabinets less than 30 inches (750 mm) above finished floor.
         c). Tops of cabinets over 78 inches (1980 mm) above finished floor and not visible from an upper level.
   b. Wood Species and Veneer Cut: Provide materials that are selected and arranged for compatible grain and color. Do not use materials adjacent to one another that are noticeably dissimilar in color, grain, figure, or natural character markings.
   c. Plain Sawn Oak
      1). Lumber:
a). Exposed and semi-exposed: Plain sawn Red Oak, wheat in color, NHLA Grade FAS, first and seconds or better.
b). Unexposed: Select grade hardwood of a species suitable for the specified purpose.
c). All lumber shall be clean and free of defects; kiln and air dried to uniform moisture content of 6 percent.

2). Veneer:
   a). Exposed: Plain sliced Red Oak, grade A, narrow heart, wheat in color.
      (1). Color and Matching:
         (a). Maximum sapwood allowed: 5%.
         (b). Color streaks or marks allowed.
         (c). Slight color variation.
         (d). No sharp contrast at veneer joints.
      (2). Natural Characteristics:
         (a). Small conspicuous burls and pin knots: combined average not to exceed 4 per 10 square feet (1 m²).
         (b). Conspicuous burl size: 3/8 inch (9.5 mm), maximum.
         (c). Pin knot size, dark part: 1/8 inch (3.2 mm), maximum.
         (d). Pin knot size, total: ¼ inch (6.4 mm), maximum.
         (e). Slight cross bars allowed.
      (3). Manufacturing Characteristics:
         (a). Rough cut or ruptured grain is not allowed.
         (b). Blended repaired tapering hairline Splits: two 1/16 inch (1.6 mm) x 6 inch (152 mm) on end panels only.
         (c). Repairs: very small blending allowed.
      (4). Flitch Width, Face Components: 5 inches minimum, except for outside components.
   b). Semi-Exposed: Plain Sawn Red Oak, Grade B.
   c). Unexposed: Any cut of hardwood veneer, grade 4 or better.
   d). Layup pattern: Book matched

2. Plywood
   a. Typical, Unless Otherwise Noted: Hardwood Veneer Plywood
      1). Product shall be provided with hardwood face veneers as specified above.
      2). Plies:
         a). ¾ inch (19 mm): minimum 7-ply, including face veneers.
         b). 1 inch (25 mm): minimum 9-ply, including face veneer.
      3). Physical Properties:
         a). Screwholding: 355 lb at face.
         b). Average modulus of rupture: 7346 psi (50.65 N/mm²).
   b. Drawer and Door Fronts: ANSI A208.1 M3 Grade Industrial Particleboard Core Plywood.
      1). Product shall be provided with hardwood face veneers as specified above.
      2). Plies:
         a). 3-ply, including face veneers.
3). Minimum Physical Properties:
   a). Screwholding: 247 lbs at face, 225 pounds at edge.
   b). Average modulus of rupture: 2,393 lb/in2.
   d). Hardness: 500 lbs.

   c. Drawer box back, front and sides: Finnish or Baltic Birch Plywood

3. Hardboard: Dry process S2S hardboard made from compressed exploded wood fibers.

4. Edgeband/Facer: 1/8 inch (3 mm) hardwood; species as described above.

5. Dowels: 8 mm, diameter, minimum, hardwood, laterally fluted with chamfered ends.

6. Glue: Type 2 or Type 3 water resistant glue with gluing done in clamps and jigs.

7. Finish for Wood Laboratory Components:
   a. All wood components shall be fully sanded on all surfaces including the underside of exposed components, glazed door element inside edges, penetrations for the attachment of drawer heads, screws attaching adjacent cabinets, cutouts at grilles, and all other such locations. The final installation shall present no rough, splintered, or unfinished surfaces at any visible, exposed, semi-exposed, or touchable locations. This does not apply to components of surfaces which will be fully concealed in the final installation.
   b. Finish processes (stains and finishes) shall be by means of compression spray or a UV roll coater, providing high-transfer efficiency low waste generation. Solvent applied coatings are not acceptable and will not be considered. Manufacturer shall supply documentation that waste generated during the finishing process, is a non-hazardous material, eliminating liquid waste disposal in landfills.

   1). Chemically Resistance Finish: Finish for all wood products shall be environmentally friendly, highly chemically resistant, water-borne, laboratory-grade finish that satisfies the requirements specified herein for chemical and durability resistance. A letter from a third-party validator, verifying independent test results, shall be submitted.
   2). Operator Protection: The application shall be convenient and easily mastered, in a custom spray booth. The finish process shall be cleanly contained and shall have no solvent odor, and shall be applied in an air-conditioned room.
   3). VOC Emissions: Water-borne finishes shall be sprayed and cured with a near zero (2.0 lbs. per gallon for ‘clean finish’) VOC (Volatile Organic Compounds) emissions.
   4). Offgasing: After all wood products have cooled from the curing ovens, the coating shall be firm and stable. No further emissions or “Offgasing/Decomposition” vapors shall occur at room temperature.

   c. Manufacturer may uses either of the following finish systems:

   1). Customized, high-solids, cross-linked, ultraviolet light (UV)-cured coating developed for durability, including abrasion, chemical, impact, and scratch resistance, for flat-line applications. Coatings shall have little or no VOCs.
   2). Chemical-resistant modified acrylic urethane finish with built-in UV blocker, or equal, applied over permanent wood stain.

   d. Stain Color:

   1). Match No. 102 Seaside Oak as manufactured by Kewaunee Scientific Corporation, subject to Architect’s approval.

   e. Application:
1. Finish application and sequence shall be as recommended and designed by the manufacturer for a high quality, laboratory-grade wood casework finish.

2. Preparation: Sand exposed and semi-exposed surfaces smooth, free from dirt and defects.

3. Stain application: Apply stain of color selected to all exposed and semi-exposed casework surfaces. Apply in a manner to achieve a match with the selected color sample upon completion of application of the finish.

4. Finish application: Apply chemical resistant top finish to all stained surfaces. Apply to doors after any notching for hinges has been performed. Finished surfaces shall be even, water-clear and bright. Cloudy or muddy finishes carrying tinting pigments will not be acceptable.

8. Glass: Framed glass doors:
   a. 1/8 inch (3mm) to 7/32 inch (5.5 mm) nominal tempered glass.
   b. Without imperfections or marred surfaces.
   c. All glass should have etched safety information, readable from outside the cabinet.

E. Construction:

1. Base Cabinets:
   a. Assembly: Dowel and/or mortise-and-tenon joinery secured with countersunk screws and pressure-glued.
   b. Cabinet Top:
      1). Front rail of ¾ inch plywood x 2¼ inches (57 mm) or 1 inch (25 mm) x 3 inches (76 mm) hardwood. Back rail: ¾ inch plywood or hardwood, 3-3/4 inches tall.
   c. Cabinet Bottom: ¾ inch (19 mm) thick plywood. Set flush and join to cabinet end panels. Front edge shall be edgebanded.
   d. Cabinets Ends/Sides and Backs Exposed to View from the Outside: ¾ inch (19 mm) thick plywood.
      1). Side panels and end panels: edgeband front edge and bottom edge.
   e. Cabinet Backs, Exposed to View from the Inside at Open Units and Units with Glazed Doors: 1/4 inch (19 mm) thick veneer core plywood.
   f. Cabinet Back, Semi-Exposed and Unexposed:
      1). Removable hardboard, 1/4 inch (6 mm) thick.
      2). Sink base back shall be half-height construction to allow for plumbing and sink waste connection.
      3). Provide split back on drawer cabinets.
   g. Cabinet Base: 3¾ inches (95 mm) x ¾ inch (19 mm) front hardwood or veneer core plywood toe space rail, mounted between end panels, forming a 4 inch (102 mm) high x 2½ inch (63 mm) deep toe space, closed to cupboard bottom. Secure rails to cabinet end panels.
   h. Shelves: 1 inch (25 mm) thick full-depth, 9-ply hardwood plywood. Full-depth is defined as a shelf whose front edge is within ½ inch (13mm) of the face of the cabinet when the shelf is fully back in the cabinet.
      1). Front edge of shelves shall be edgebanded.
      2). Shelf Adjustment: All shelves shall be adjustable on 32 mm centers.
      3). Shelf Tolerance: Shelves shall fit into cabinets or into shelf supports with a tolerance of 1/16 inch per side maximum.
   i. Drawer construction:
1). Drawer box back, front and sides shall be of ½ inch (13 mm), 9-ply Finnish or Baltic Birch veneer plywood, with eased top edge, finished with a Gloss Level 7 polyester acrylic finish. The top edges of the completed drawer bodies shall be very smooth to the touch and shall not present any rough or splintered surfaces. Sides shall be full height with 1 inch (25 mm) clearance to frame opening. Drawers shall be a minimum of 18 inches front to back.

2). Acceptable drawer joinery options:
   a). Dowel: Glued under pressure; 32mm, minimum, dowel spacing to 4 inches (102 mm) high, 64 mm dowel spacing above 4 inches (102 mm).
   b). Multiple Dovetail: Tight fitting and glued.

3). Drawer bottom shall be Baltic Birch veneer plywood. Bottom shall be grooved into the 4 sided drawer box and sealed with hot melt glue process around entire drawer bottom perimeter.
   a). Drawers up to 24 inches wide: 3/8 inch (9mm) thick 7-ply Baltic Birch veneer plywood.
   b). Drawers greater than 24 inches wide: 1/2 inch (13 mm) thick 9-Ply Baltic Birch veneer plywood.

j). Door and Drawer Heads: shall be ¾ inch (19 mm) thick plywood with edgebanding. Edges shall be as specified previously in this section. Drawer heads shall be screwed to drawer box.

k). Flush Panels: As described in the Design Requirements section of this specification.

l). Vertical Dividers: Full height dividers shall be 1½ inch (38 mm) thick plywood. Edgeband exposed edge.

m). Front Horizontal intermediate Rail: ¾ inch (19 mm) x 1½ inches (38 mm) exposed hardwood rail shall be provided between doors and drawers. For all drawer units at benches where service fitting connections are not accessible via an adjacent knee opening filler or cabinet filler panel, drawer units to be provided with Keku fasteners (Keku fasteners not required at other locations). The drawer unit intermediate horizontal and vertical box frames must be removable. These components shall be assembled with Keku suspension fittings as manufactured by Häfele America Co. or approved so these members are easily removable at any time with no special tools to gain access to concealed piped services behind.

n). Intermediate Back Rail: 1½ inch (38 mm) x ¾ inch (19 mm) hardwood lumber to accept hardboard security panel between drawers.

o). Security Panels: Provide hardboard security panels, 1/8 inch (3 mm) thick, in frames when keyed-different locks are specified, or where individual padlock hasps are indicated. Inset security panel into frame on all four sides.

2. Wall, upper and tall cases:
   a). Shall be manufactured with materials and joinery methods as specified for base units, unless otherwise indicated.
   b). Edgebanding:
      1). Wall cabinets side panels: Edgeband front and bottom edges. Wall cabinet end panels: Edgeband front, bottom, and top edges.
      2). Edgeband front and top edges of upper cabinet side and end panels.
      3). Edgeband front, top, and bottom edges of tall cabinet side and end panels.
   c). Cabinet Interior Backs: 1/4 inch thick veneer core plywood, typical for all exposed, and semi-exposed interior backs.
   d). Hardwood plywood tops: 1 inch (25 mm) thick with front edge edgebanded.
e. Wall and upper case hardwood plywood bottoms: 1 inch (25 mm) thick. Tall case hardwood plywood bottoms ¾ inch (19 mm) thick. Edgeband front edges.

f. Bottom hardwood kick rail on tall cases: ¾ inches (95 mm) x ¾ inch (19 mm) front hardwood or veneer core plywood toe space rail, mounted between end panels, forming a 4 inch (102 mm) high x 2½ inch (63 mm) deep toe space, closed to cupboard bottom. Secure rails to cabinet end panels.

g. Solid doors shall be the same construction as specified for base cabinets.

h. Framed-glazed doors: Hardwood construction, ¾ inch (19 mm) x 2¾ inch (70 mm) machined to accept glass. Ease all edges, interior and exterior, including those that frame the glazing. Provide extruded vinyl retaining molding on interior designed so glass can be replaced without tools.

i. Shelves: 1 inch (25 mm) thick full depth, 9-ply hardwood plywood. Full-depth is defined as a shelf whose front edge is within ½ inch (13mm) of the face of the cabinet when the shelf is fully back in the cabinet.

1). Front edge of shelves shall be edgebanded.

2). Front edge of open shelves:
   a). Retainer Rail: Retainer rail as specified elsewhere in this section and detailed on drawings.

3). Shelf adjustment:
   a). Wall units: All shelves shall be adjustable on 32 mm centers.
   b). General purpose tall units: One fixed shelf. All others shall be adjustable on 32 mm centers.

3. Aprons and leg assemblies:
   a. Apron: Not less than ¾ inch (19 mm) x 4-5/16 inch (110 mm) hardwood.
   b. Legs: Not less than 2 inch (50 mm) x 2 inch (50 mm) hardwood.
   c. Leg rails: Not less than 1¼ inch (32 mm) x 2½ inch (63 mm) hardwood.
   d. All exposed edges of legs and aprons shall be eased, sanded smooth, and finished per requirements described above for wood laboratory casework components.

4. Wood Casework Construction Performance:
   a. Base cabinets shall be constructed to support a uniformly distributed load of 200 lbs. minimum per square foot (1000 kg/m²) of cabinet top area (total maximum of 2000 lbs. (900 kg)), including working surface, without permanent distortion or interference with door and drawer operation.
   b. Base cabinets shall be constructed so that when supported on both back corners and one front corner; with a counterweight load of 350 pounds placed on the rear corner behind the supported front corner; and with a load of 200 pounds placed on the unsupported corner – there shall be no permanent damage after 24 hours of loading. Maximum allowable deflection shall not exceed 1/8 inch.
   c. Swinging doors mounted on base units shall support a 200 lb. (113 kg) load located at a test point 12 inches (305 mm) measured horizontally from hinge along the top edge of door through a swing of 160 degrees. Weight test shall allow nominal temporary deflection, but no permanent distortion. Door assembly shall be twist-resistant and rigid, and shall close in a flat plane against the cabinet to permit the door catch at top of door to function properly.
   d. Drawers shall be constructed so that they will support a 150 pound load hung on the drawer head centerline, with the drawer opened 13 inches (330mm), for five minutes. There shall be no interference with the normal operation of the drawer and the drawer head should remain tightly fastened to the drawer.
e. Drawers shall be constructed so that a drawer that is removed and supported on four corners will support a 10 pound sand or shot bag dropped from a height of 24 inches (610mm) without damage.

f. Drawers shall be constructed so that a drawer that is removed and supported at a 45 degree angle shall be capable of withstanding three impacts of a 2 inch (51mm) diameter, 12 inch (305mm) long steel rod (approximately 10 pounds in weight) released from 13 inches (330mm) from the front and back of the drawer. The drawer joinery shall remain intact and the drawer shall operate normally when placed back into the casework cabinet.

g. Drawer mechanical suspension systems shall be designed and attached to that a drawer uniformly loaded with 75 pounds of sand or shot bags shall operate freely without binding over its full range for 50,000 cycles at a rate not exceeding 10 cycles per minute. The force required to open and close the loaded drawer for the purposes of this test shall not exceed 8 pounds.

h. Shelves shall be designed and supported to that they can support a load of 40 pounds per square foot, up to a maximum of 200 pounds per shelf, for 24 hours with no more than 0.35 inches (9mm) of deflection maximum.

F. Hardware: As specified elsewhere in this Section.

G. Wood Finish Chemical Resistance Performance Requirements:

1. Manufacturer shall submit wood finish chemical resistance performance test results. Testing to be performed by independent testing agency.

2. Procedure: Place panel on a flat surface, clean with soap and water and blot dry. Condition the panel for 48-hours at 73º +/- 3ºF (23º +/- 2ºC) and 50 +/- 5% relative humidity or the currently accepted guideline set by ASTM. Test the panel for chemical resistance using forty-nine different chemical reagents by one of the following methods. For both methods, leave the reagents on the panel for a period of one hour. Wash off the panel with water, clean with detergent and naptha, and rinse with deionized water. Dry with a towel and evaluate after 24-hours at 73º +/- 3ºF (23º +/- 2ºC) and 50 +/- 5% relative humidity, or the currently accepted guideline set by ASTM.

   a. Method A: Test volatile chemicals by placing a cotton ball saturated with reagent in the mouth of a 1 ounce (29.574cc) bottle and inverting the bottle on the surface of the panel.

   b. Method B: Test non-volatile chemicals by placing five drops of the reagent on the surface of the panel and covering with a 24mm watch glass, concave side down.

3. Rating System: Evaluations shall use the following rating system:

   - Level 0 No detectable change.
   - Level 1 Slight change in color or gloss.
   - Level 2 Slight surface etching or severe staining.
   - Level 3 Pitting, cratering, swelling, or erosion of coating. Obvious and significant deterioration.

4. Acceptance Level:

   a. Individual test results for the specified 49 reagents shall be within the Range for that reagent as specified on the table below.

   b. There shall be no more than four (4) Level 3 conditions.

5. Table of reagents:

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Chemical Reagent</th>
<th>Test Method</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acetate, Amyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>2.</td>
<td>Acetate, Ethyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>3.</td>
<td>Acetic Acid, 98%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>Test No.</td>
<td>Chemical Reagent</td>
<td>Test Method</td>
<td>Range</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------------------</td>
<td>-------------</td>
<td>-------</td>
</tr>
<tr>
<td>4.</td>
<td>Acetone</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>5.</td>
<td>Acid Dichromate, 5%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>6.</td>
<td>Alcohol, Butyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>7.</td>
<td>Alcohol, Ethyl</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>8.</td>
<td>Alcohol, Methyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>9.</td>
<td>Ammonium Hydroxide, 28%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>10.</td>
<td>Benzene</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>11.</td>
<td>Carbon Tetrachloride</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>12.</td>
<td>Chloroform</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>13.</td>
<td>Chromic Acid, 60%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>14.</td>
<td>Cresol</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>15.</td>
<td>Dichloroacetic Acid</td>
<td>A</td>
<td>0-3</td>
</tr>
<tr>
<td>16.</td>
<td>Dimethylformamide</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>17.</td>
<td>Dioxane</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>18.</td>
<td>Ethyl Ether</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>19.</td>
<td>Formaldehyde, 37%</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>20.</td>
<td>Formic Acid, 90%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>21.</td>
<td>Furfural</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>22.</td>
<td>Gasoline</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>23.</td>
<td>Hydrofluoric Acid, 37%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>24.</td>
<td>Hydrofluoric Acid, 48%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>25.</td>
<td>Hydrogen Peroxide, 30%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>26.</td>
<td>Iodine, Tincture of</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>27.</td>
<td>Methyl Ethyl Ketone</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>28.</td>
<td>Methylene Chloride</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>29.</td>
<td>Monochlorobenzene</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>30.</td>
<td>Naphthalene</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>31.</td>
<td>Nitric Acid, 20%</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>32.</td>
<td>Nitric Acid, 30%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>33.</td>
<td>Nitric Acid, 70%</td>
<td>B</td>
<td>2-3</td>
</tr>
<tr>
<td>34.</td>
<td>Phenol, 90%</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>35.</td>
<td>Phosphoric Acid, 85%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>36.</td>
<td>Silver Nitrate Saturated</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>37.</td>
<td>Sodium Hydroxide 10%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>38.</td>
<td>Sodium Hydroxide 20%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>39.</td>
<td>Sodium Hydroxide 40%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>40.</td>
<td>Sodium Hydroxide Flake</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>41.</td>
<td>Sodium Sulfide Saturated</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>42.</td>
<td>Sulfuric Acid, 33%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>43.</td>
<td>Sulfuric Acid, 77%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>44.</td>
<td>Sulfuric Acid, 96%</td>
<td>B</td>
<td>1-3</td>
</tr>
<tr>
<td>45.</td>
<td>Sulfuric Acid 77% &amp; Nitric Acid 70% equal parts</td>
<td>B</td>
<td>1-3</td>
</tr>
<tr>
<td>46.</td>
<td>Toluene</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>47.</td>
<td>Trichloroethylene</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>48.</td>
<td>Xylene</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>49.</td>
<td>Zinc Chloride, Saturated</td>
<td>B</td>
<td>0</td>
</tr>
</tbody>
</table>

2.2  METAL LABORATORY CASEWORK AND TABLES

A. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be the provided by a single
manufacturer. Corrosive and flammable liquid/solvent storage cabinets may also be provided by
the manufacturers listed with their descriptions.

1. Laboratory Casework:
   a. Air Master Systems, 6480 Norton Center Drive, Muskegon, MI 49441 Tel 231 798-1111.
   b. Bedcolab Ltd, 2305 Francis Hughes Avenue, Laval, Quebec, Canada H7S 1H5 Tel 514 384-2820.
   c. CiF Lab Solutions, 53 Courtland Avenue, Vaughan, Ontario, Canada L4K 3T2 Tel: 905 738-5821.
   d. ICI scientific, 1865 Highway 641 North, Paris, TN 38242-8814 Tel: 731-642-4251.
   e. Kewaunee Scientific Corporation, P O Box 1842, Statesville, NC 28687 Tel: 704 873-7202.
   f. Mott Manufacturing Ltd., 452 Hardy Road, P. O. Box 1120, Brantford, ON, Canada N3T 5T3 Tel: 519 752-7825
   g. Approved substitution.

B. Metal Laboratory Casework

1. Design Requirements:
   a. Door and drawer front design: Square edged inset metal construction with all front surfaces above the toe space in the same plane.
   b. Pulls on doors shall be mounted vertically and on drawers horizontally.
   c. All tall cases shall be provided with toe space to match base units.
   d. All cabinets shall be constructed and finished to be suitable for use as stand-alone units and to permit future rearrangement without the need for additional parts or finish.
   e. Widths of drawers in knee opening rails shall not be less than 24 inches (600 mm) or the width of the rail whichever is the lesser.
   f. Cabinets below fume hoods that conflict with ductwork, cup sinks, or waste connections shall be 19 inches deep to accommodate any obstructions.

2. Materials:
   a. Steel: Cold-rolled furniture stock sheet steel, prime grade, roller leveled.
      1). Steel shall be treated at the mill to be free of scale, ragged edges, deep scratches, or other injurious effects.
      2). All gauges indicated are to be U.S. standard.
   b. Glass: Framed glass doors:
      1). 1/8 inch (3mm) to 7/32 inch (5.5 mm) thick tempered glass.
      2). Without imperfections or marred surfaces.
      3). All glass should have etched safety information, readable from outside the cabinet.

3. Base, Wall, Upper, and Tall Cabinets:
   a. General:
      1). Exterior corners: shall be spot and arc welded with heavy back up reinforcement at exterior corners. All face joints shall be arc welded and ground smooth to provide a continuous flat plane.
      2). All units shall have a cleanable smooth interior. Front and rear posts, reinforcing members or channel uprights shall be enclosed full heights on all cabinet openings.
      3). End Uprights shall be formed into not less than a channel formation at top, bottom, back and front.
4). The edge of the vertical uprights shall be formed to provide a strike for doors and drawers, and shall be perforated for the support of drawer channels, intermediate rails and hinge screws.

5). An upright filler shall be screwed in place in all cupboard units to close the back of the channel at front of the upright and to provide a smooth interior for the cupboard to facilitate cleaning.

6). The upright filler shall be perforated with shelf adjustment holes at no more than ½ inch (12.7 mm) centers.

7). The inside front of the upright shall be further reinforced with a full height 14 gauge (2.0 mm thick) hinge reinforcement angle.

8). Die Formed Gussets: shall be furnished in each bottom corner of base units to insure rigidity, and a 3/8 inch (10 mm) -16 leveling bolt, 3 inches (75 mm) long, shall engage a clinch nut in each gusset. Each leveling bolt and gusset shall be capable of supporting 500 lbs (225 kg). (Each unit shall support 2000 lbs. (900 kg) uniformly distributed on a work top.) Provide caps at all penetrations provided to access leveling devices.

b. Cabinet Base:

1). Case bottom and bottom rail shall be formed of one piece of metal except in corner units and shall have both sides and back formed up or down and shall be offset in front to provide a door and drawer recess rabbet.

2). Toe Space Rail: shall extend up and forward to engage bottom rail to form a smooth surfaced toe space, 3 inches (75 mm) deep and 4 inches (100 mm) high. Whenever the base is omitted for units to be set on building bases or separate metal bases, the toe space rail shall extend back 4½ inches (115 mm).

c. Cabinet Back, Unexposed: Cabinet back shall consist of a top and bottom rail, channel formed for maximum strength and welded to back and top flange of end uprights, with space between left open for access to plumbing lines. All units shall be provided with removable back panels.

1). Sink units shall be provided with fixed half-height backs to allow plumbing lines to enter and exit the cabinet through the open area.

d. Shelves: shall be full depth formed down ¾ inch (19 mm), back 7/8 inch (22 mm) and up ¼ inch (6 mm) at front and rear and formed down at ends ¾ inch (19 mm). Shelves over 36 inches (914 mm) in length shall be additionally reinforced by a flanged channel shaped member electro-welded to underside of shelf. Shelves shall be adjustable. Full-depth is defined as a shelf whose front edge is within ½ inch (13mm) of the face of the cabinet when the shelf is fully back in the cabinet.

1). Restraint: At open shelf units, provide retainer rail as specified elsewhere in this section and detailed on drawings.

e. Doors: shall be readily removable and hinges easily replaceable. Hinges shall be applied to the case and door with screws. Welding of hinges to either case or door will not be acceptable.

f. Door and Drawer Heads:

1). Metal, Flush Inset: shall be a two-piece sheet steel assembly of ¾ inch (19 mm) overall thickness to consist of an inner pan formed as an extension of the drawer body, an outer pan having a channel formation on all four sides, and the interior space filled with a non-organic sound deadening material at the time of assembly. Door Pans and Drawer Heads shall be painted inside and out prior to assembly.
a). All four corners of door and drawer heads shall be welded closed and ground smooth to eliminate exposure of raw edges and open gaps.

b). Glazed Hinged Door Construction: Glazed swinging doors shall be 3/4 inch thick and consist of an inner and outer door pan welded to form a single unit. Outer door pan shall be 18 gauge steel, formed into a channel or flanged shape at all four sides. It shall be pierced and formed to create a 3 inches wide frame with a beveled edge around the glass opening in the center of the door. Inner door pan shall be 18 gauge steel, flanged at all four sides, pierced for a glass opening in center of the door, with 16 gauge hinge reinforcements welded in place. Glazing shall be held in place by a rubber or vinyl gasket around the entire edge of the glass. Outer door pan shall be prepared as necessary to accept attachment of pulls as specified elsewhere in this section.

g. Drawer Construction:
   1). Drawer bodies shall be made in one-piece construction including the bottom, two sides, back and inner front. They shall be fully coved at interior bottom on all four sides for easy cleaning. Sides shall be full height with ½ inch (13 mm) clearance to frame opening. Drawers shall be a minimum of 18 inches front to back.
   2). Drawer Suspension: Refer to Drawer Slides under Hardware section.
   3). Drawer stops: shall be provided to insure smooth, quiet operation at point of contact with cabinet front.

h. Top Horizontal Rail: Provide on base cabinets such that rail shall interlock within the flange at top of end panels for strength. Reinforcements shall be provided at all front corners for additional welded strength between vertical and horizontal case members.

i. Intermediate Rails: Provide on base cabinets such that rails shall be provided between doors and drawers, but shall not be provided between drawers unless made necessary by locks in drawers. When required, intermediate rails shall be recessed behind doors and drawer fronts, and designed so that security panels may be added as required.

j. Intermediate Vertical Uprights: shall be furnished to enclose cupboards when used in a unit in combination with a half width bank of drawers. However, to allow storage of large or bulky objects, no upright of any type shall be used at the center of double door cupboard units.

k. Security Panels: Provide security panels in frames between drawers and cabinets within a cabinet where keyed different locks are indicated.

l. Knee Space Service Strip Cover Panels where specified, shall be 18 gauge (1.3 mm thick) steel, of the same finish as cabinets, and shall be furnished at open spaces under counter top where no cabinets occur. They shall be easily removable and shall cover piping from underside of top of service ledge to floor.

m. Provide filler panels where required between cabinets, at corner intersections of cabinets, between cabinets and walls and wherever else required for a complete finished installation. For tall cabinets, filler panels shall be provided for vertical face and top. For wall cabinets, filler panels shall be provided for vertical face, top and bottom. Filler panels shall follow the profile of toe kicks.

4. Metal-Framed Laboratory Tables

   a. Tops: Refer to Laboratory Furnishing drawings for top materials, as described in the Laboratory Work Surfaces section.

   1). Tops shall be mechanically attached to the table frame with a minimum of six concealed metal angle brackets screwed into the inside of the table.
frame and the bottom of the work surface. Metal angle bracket may be stainless steel, zinc-coated steel, or powder-coated steel. Screws shall be dome-head, with a minimum size of No. 5, ½ inch long, or otherwise sufficient to firmly and permanently secure the benchtop to the table frame allowing that the table may be picked up by the top.

b. Electrical receptacles: Tables shown with electrical receptacles shall be pre-wired, including cutouts for electrical receptacles, black cord, straight NEMA 5-20P plug, back boxes, gray NEMA 5-20R decora-style electrical receptacles, stainless steel faceplates, wiring, and junction boxes as required for a complete functional assembly.

1). The first electrical device wired from the main cord shall be a 20 amp, GFCI outlet with downstream protection capability.
2). Ensure wiring to downstream receptacles is connected to the downstream outlets such that GFCI protection is provided to downstream outlets.
3). Cover plates of downstream outlets to be engraved to note that GFCI protection is provided via upstream receptacle.
4). UL Listing:
   a). The table assembly shall be UL61010A-1 tested and labeled.

c. Leveling Glides and Leg Shoes:

1). Each leg other than those fitted with casters shall have leveling glides: (2 inch) (48 mm) diameter, two-piece pivot construction, steel housing, non-marring, phenolic or translucent plastic insert, (1/2 inch) (12 mm) diameter, minimum (1 1/2 inch) (36 mm) long zinc plated stems. Each glide shall have a load bearing capacity of 150 lbs.
2). Each leg other than those fitted with casters and adjustable-height legs, shall have leg shoes: Black coved vinyl or rubber leg shoe, 2 inches (50 mm) in height.

d. Casters: Where indicated on Laboratory Furnishing drawings, provide sets of 3 ½ inch (89 mm) diameter wheels with self-lubricating bearing, rated to carry 250 pounds (113 kg) minimum each. Each caster must swivel and have a locking brake at front wheels. Wheel shall be of molded polyurethane tread mechanically locked to a polyolefin core. Movable tables to have all 4 swivel and locking casters.

e. Adjustable-Height Legs: Where indicated on Laboratory Furnishing drawings, provide a stainless steel insert at the bottom of each leg. Height of each insert shall be adjustable in 2 inch (50mm) increments using stainless steel pins. This shall result in a work-surface top height range between 30 inches (750mm) and 38 inches (1000mm). Include leveling glide at bottom of each insert.

f. Construction:

1). Table rails and legs shall be fully welded into a single-piece table frame structure. No mechanical joints between members are permitted.

g. Rails: Not less than 1½ inch x 4½ inch 16 gauge (38 x 114 x 1.6 mm) channel steel sections, reinforced as necessary for leg attachment.

h. Legs: Not less than 2 inch x 2 inch 16 gauge (50 x 50 x 1.6 mm) square tubular steel sections.

i. Materials and Finish: Refer to Metal Fabrications specifications in this Section for material and finish requirements.

5. Aprons and leg assemblies:

a. Apron: Not less than 1½ inch (38 mm) x 4 inch (114 mm) 16 gauge (x 1.6 mm thick) channel steel sections, reinforced as necessary for leg attachment.
b. Legs: Not less than 2 inch (50 mm) x 2 inch (50 mm) 16 gauge (1.6 mm thick) square tubular steel sections.

c. Leg rails: Not less than 1½ inch (32 mm) x 2½ inch (63 mm) 16 gauge (1.6 mm thick) steel sections, reinforced as necessary for leg attachment. Each leg shall have a recessed leveling screw and a black, coved vinyl or rubber leg shoe, 2 inches (50 mm) in height.

6. Fume Hood Cabinets:

a. Purpose-designed metal cabinet with fixed panel above door to conceal cup sink and plumbing.

b. Provide metal fume hood cabinets where adjacent cabinetry below a fume hood is also metal.

7. Corrosives Storage Cabinets:

a. Manufacturers:

1). Manufacturers of metal laboratory casework.

2). Justrite Manufacturing Company, 2454 Dempster St., Suite 300, Des Plaines, IL 60016 Tel: 800 798-9250.

3). Approved substitution.

b. Purpose-designed lined metal cabinet. Base cabinets may have either of the following two types of linings. Tall cabinets must only have Type 2 lining with a 100% seamless non-porous flame-coated thermoplastic liner.

c. Type 1 Lining: Cabinet shall be complete lined with a polypropylene or polyethylene liner with sealed or seamless intersections between panels. Liner shall be the full depth of the cabinet. No metal of any type shall be exposed within the lined interior of the cabinet. Screw-heads, if required, shall be covered with hinged-type (not snap-on) plastic screw-head covers.

1). Shelf: Removable full-depth polypropylene or polyethylene shelf. Full-depth is defined as a shelf whose front edge is within ½ inch (13mm) of the face of the cabinet when the shelf is fully back in the cabinet.

d. Type 2 Lining: All interior surfaces of the cabinet shall be coated with a 100% seamless non-porous flame-coated thermoplastic liner. Liner shall be applied to all interior walls, ceiling, sump, door interiors, and shelving. Basis of design: Plascore PPA-751, or Justrite Chemcor. No known equal.

1). Shelf: Removable adjustable full-depth metal shelf coated with lining material. Full-depth is defined as a shelf whose front edge is within ½ inch (13mm) of the face of the cabinet when the shelf is fully back in the cabinet.

2). Refer to drawings for required quantity of shelves.

e. Label: "CORROSIVES" in conspicuous silk-screened lettering. Stick-on decals are not acceptable. Size and style of lettering shall match the Flammable Liquid/Solvent Storage Cabinet label. Lettering shall be 2 1/2 inches tall. Color of lettering shall be red. If cabinet color is red, lettering shall be yellow.

f. Locks: Cabinet doors shall be lockable. Lock shall have no metal parts exposed within the lined interior.

g. Venting:

1). Cabinets below or adjacent to fume hoods: Provide and install 2 inch (50 mm) diameter schedule 40 PVC vent pipe and PVC fittings. Termination of vent pipe maybe one of the following:

a). Extend vent pipe 4 inches (100 mm) above dished worktop, behind the baffle in the hood, as shown on the drawings. Provide hole through fume hood work surface above the corrosive storage cabinet
to accommodate 2 inch (50 mm) diameter vent pipe. Seal gap around penetration with clear silicone sealant.

b). Extend vent pipe up within the fume hood side wall and vent through the hood side wall liner behind the upper portion of the fume hood baffle.

2). Cabinets not below or adjacent to fume hoods: Vent connection to exhaust duct system shall be under Division 23. Provide hole in back of cabinet to accept exhaust connection.

h. Seismic Anchor: Provide seismic anchor for freestanding cabinets. Seismic anchors may be floor or wall attachments, but shall not attach to adjacent casework or work surfaces. Seismic anchors shall be accessible without removal of laboratory casework, furnishings, or equipment.

8. Flammable Liquid/Solvent Storage Cabinets:

a. Manufacturers:

1). Manufacturers of metal laboratory casework.
2). Eagle Manufacturing Company, 2400 Charles St., Wellsburg, WV 26070 Tel: 304 737-3171.
3). Justrite Manufacturing Company, 2454 Dempster St., Suite 300, Des Plaines, IL 60016 Tel: 800 798-9250.
4). Approved substitution.

b. Purpose-designed double-walled metal cabinet for the storage of flammable, combustible and solvent liquids.


d. Label: "FLAMMABLE - KEEP FIRE AWAY" in conspicuous silk-screened lettering. Stick-on decals are not acceptable. Size and style of lettering shall match that of the Corrosive Storage Cabinet label. "FLAMMABLE" lettering shall be 2 1/2 inches tall. "KEEP FIRE AWAY" lettering shall be 2 inches tall. Color of lettering shall be red. If cabinet color is red, lettering shall be yellow.

e. Locks: Cabinet doors shall be lockable.

f. Floor pan: Provide a 2 inch (50 mm) deep liquid tight pan to cover the entire bottom of the cabinet to contain liquid leaks and spills.

g. Shelves: Provide heavy-duty full-depth metal shelves using pan-type construction to create a liquid-tight containment tray.

1). Refer to drawings for quantity of shelves.

h. Casters: Provide cabinets with lockable casters where indicated on the Laboratory Furnishing drawings.

i. Standards:

1). Comply with the requirements of OSHA and NFPA 30.
2). Comply with the requirements of Uniform Fire Code and the International Fire Code.
3). Cabinets should be certified and labelled with UL 1275 and FM 6050 labels.

j. Flammable liquid/solvent storage base cabinets shall not be vented. Seal vent openings with bungs as provided by manufacturer.

k. Venting of tall cabinets:

1). Remove both metal bungs from cabinet outlets and replace with flash arrestors provided by manufacturer. Connection with 2 inch (50 mm) black iron vent piping to the HVAC systems as shown on LF drawings shall be under Division 23.
2). Vents from multiple cabinets shall not be manifolded prior to connection to the building system

l. Electrical grounding:
   1). Provide each flammable liquid / solvent storage cabinet with an externally mounted grounding conductor screw terminal for up to No. 8 AWG conductor, mounted at the top of the cabinet.
   2). Connection from the equipment grounding bus at the lab branch circuit panel to the storage cabinet terminal shall be under Division 26.

m. Seismic Anchor: Provide seismic anchor for freestanding cabinets and cabinets located below fume hoods designated to be removable for access for persons with disabilities. Seismic anchors may be floor or wall attachments, but shall not attach to adjacent casework or work surfaces. Seismic anchors shall be accessible without removal of laboratory casework, furnishings, or equipment. Anchor attachment shall not void UL listing.

9. Metal Casework Construction Performance: Base cabinets shall be constructed to support a uniformly distributed load of 200 pounds minimum per square foot (1000 kg/m²) of cabinet top area (total maximum of 2000 pounds (900 kg)), including working surface without objectionable distortion or interference with door and drawer operation.
   a. Base cabinet corner gussets with leveling bolts shall support 500 pounds (225 kg) per corner, at 1½ inch (38 mm) projection of the leveling bolt below the gusset.
   b. Each adjustable and fixed shelf 4 feet (1219 mm) or shorter in length shall support an evenly distributed load of 40 pounds per square foot (200 kgf/m²) up to a maximum of 200 pounds (90 kg), with nominal temporary deflection, but no permanent set.
   c. Drawer assemblies shall automatically maintain alignment in cabinet opening and shall not bind during opening or closing of the drawer so as to minimize glass breakage and damage to fragile parts.
   d. Swinging doors mounted on base units shall support a 250 lb. (113 kg) load located at a test point 14 inches (356 mm) measured horizontally from hinge along the top edge of door through a swing of 180 degrees. Weight test shall allow nominal temporary deflection, but no permanent distortion. Door assembly shall be twist-resistant and rigid, and shall close in a flat plane against the cabinet to permit the door catch at top of door to function properly.

C. Hardware: As specified elsewhere in this Section.

D. Metal Casework Color: As selected by the Architect from manufacturer's full color line and complying with finish requirements described below.

E. Metal Casework Finish Requirements:
   1. Paint finish for steel laboratory products shall utilize a dry coating process with minimal waste generation. Liquid-applied coatings shall not be acceptable. Manufacturer shall supply documentation that waste generated during the painting process, is a solid, non-hazardous material.
      a. Pretreatment: Finish process shall incorporate a phosphate conversion coating during the pretreatment/cleaning operation.
      b. Operator Protection: The painting process shall be cleanly contained, have no solvent odor and be performed in an air-conditioned room.
      c. VOC (Volatile Organic Compounds) emissions shall not exceed 0.29 lbs per gallon (35 g/L).
d. Offgasing: No further emissions or "Offgasing/Decomposition" vapors shall occur at room temperature from installed finished parts.

2. Preparation: After the units have been completely welded together and before finishing, they shall be given a pre-paint treatment to provide excellent adhesion of the finish to the metal and to aid in the prevention of corrosion. Physical and chemical cleaning of the metal shall be accomplished by washing with an alkaline cleaner, followed by a spray treatment with a heated cleaner/phosphate solution and pretreated with iron phosphate spray followed by a neutral final seal prior to application of final finish. The strength of each solution shall be monitored by filtration to insure consistent quality. All treated parts shall be immediately dried in heated ovens and gradually cooled before application of the finish. Treated metal parts shall be clean and properly prepared to provide optimum adhesion of finish and resistance to corrosion.

3. Application: Electrostatically apply powder coat of selected color and bake in controlled high temperature oven to assure a smooth, hard satin finish. Surfaces shall have a chemical resistant, high grade laboratory furniture quality finish of the following thicknesses:
   a. All surfaces, exterior or interior, exposed to view, shall receive sufficient powder coat to achieve an average 1.5 mil (38 µm) film thickness with a minimum 1.2 mil (30 µm) film thickness and shall have smooth satin luster.
   b. Backs of cabinets and other surfaces not exposed to view shall have sufficient powder coat to achieve an average 1.0 mil (25 µm) film thickness.

4. All drawer bodies to be finished in matching color or in a uniform neutral color.
5. Concealed interior parts shall receive corrosion-resistant treatment.
6. Finish must be UV stable.

F. Metal Finish Performance Requirements:
1. Manufacturer shall submit metal finish performance testing results. Testing to be performed by independent testing agency.
2. Chemical resistance:
   a. Test procedure: Place samples on a flat surface, clean with soap and water and blot dry. Condition the panel for 48-hours at 73 +/- 3 degrees Fahrenheit (23(+ 2(C) and 50+ 5% relative humidity, or the currently accepted guideline set by ASTM. Test the samples for chemical resistance using forty-nine different chemical reagents by one of the following methods. For both methods, leave the reagents on the sample for a period of one hour. Wash off the sample with water, clean with detergent and naphtha, and rinse with deionized water. Dry with a towel and evaluate after 24-hours at 73 ± 3 degrees Fahrenheit (23°± 2°C) and 50± 5% relative humidity, or the currently accepted guideline set by ASTM
      1). Method A: Test volatile chemicals by placing a cotton ball saturated with reagent in the mouth of a 1 ounce (29.574cc) bottle and inverting the bottle on the surface of the sample. The cotton ball shall remain in contact with the sample for the duration of the test.
      2). Method B: Test non-volatile chemicals by placing five drops of the reagent on the surface of the sample and covering with a 24mm watch glass, convex side down.
   b. Rating System: Evaluations shall use the following rating system:
      Level 0 No detectable change.
      Level 1 Slight change in color or gloss.
      Level 2 Slight surface etching or severe staining.
      Level 3 Pitting, cratering, swelling, or erosion of coating. Obvious and significant deterioration.
c. Acceptance Level:

1). Individual test results for the specified 49 reagents shall be within the Range for that reagent as specified on the table below.
2). There shall be no more than four (4) Level 3 conditions.

d. Table of reagents:

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Chemical Reagent</th>
<th>Test Method</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acetate, Amyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>2.</td>
<td>Acetate, Ethyl</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>3.</td>
<td>Acetic Acid, 98%</td>
<td>B</td>
<td>0-3</td>
</tr>
<tr>
<td>4.</td>
<td>Acetone</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>5.</td>
<td>Acid Dichromate, 5%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>6.</td>
<td>Alcohol, Butyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>7.</td>
<td>Alcohol, Ethyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>8.</td>
<td>Alcohol, Methyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>9.</td>
<td>Ammonium Hydroxide, 28%</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>10.</td>
<td>Benzene</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>11.</td>
<td>Carbon Tetrachloride</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>12.</td>
<td>Chloroform</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>13.</td>
<td>Chromic Acid, 60%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>14.</td>
<td>Cresol</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>15.</td>
<td>Dichloroacetic Acid</td>
<td>A</td>
<td>0-3</td>
</tr>
<tr>
<td>16.</td>
<td>Dimethylformamide</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>17.</td>
<td>Dioxane</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>18.</td>
<td>Ethyl Ether</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>19.</td>
<td>Formaldehyde, 37%</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>20.</td>
<td>Formic Acid, 90%</td>
<td>B</td>
<td>0-3</td>
</tr>
<tr>
<td>21.</td>
<td>Furfural</td>
<td>A</td>
<td>0-3</td>
</tr>
<tr>
<td>22.</td>
<td>Gasoline</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>23.</td>
<td>Hydrofluoric Acid, 37%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>24.</td>
<td>Hydrofluoric Acid, 48%</td>
<td>B</td>
<td>0-3</td>
</tr>
<tr>
<td>25.</td>
<td>Hydrogen Peroxide, 30%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>26.</td>
<td>Iodine, Tincture of</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>27.</td>
<td>Methyl Ethyl Ketone</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>28.</td>
<td>Methylene Chloride</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>29.</td>
<td>Monochlorobenzene</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>30.</td>
<td>Naphthalene</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>31.</td>
<td>Nitric Acid, 20%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>32.</td>
<td>Nitric Acid, 30%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>33.</td>
<td>Nitric Acid, 70%</td>
<td>B</td>
<td>0-3</td>
</tr>
<tr>
<td>34.</td>
<td>Phenol, 90%</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>35.</td>
<td>Phosphoric Acid, 85%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>36.</td>
<td>Silver Nitrate Saturated</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>37.</td>
<td>Sodium Hydroxide 10%</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>38.</td>
<td>Sodium Hydroxide 20%</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>39.</td>
<td>Sodium Hydroxide 40%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>40.</td>
<td>Sodium Hydroxide Flake</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>41.</td>
<td>Sodium Sulfide Saturated</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>42.</td>
<td>Sulfuric Acid, 33%</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>43.</td>
<td>Sulfuric Acid, 77%</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>44.</td>
<td>Sulfuric Acid, 96%</td>
<td>B</td>
<td>2-3</td>
</tr>
<tr>
<td>45.</td>
<td>Sulfuric Acid 77% &amp; Nitric Acid</td>
<td>B</td>
<td>1-3</td>
</tr>
<tr>
<td></td>
<td>70% equal parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>46.</td>
<td>Toluene</td>
<td>A</td>
<td>0-1</td>
</tr>
</tbody>
</table>
### Test No. Chemical Reagent Test Method Range

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Chemical Reagent</th>
<th>Test Method</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>47.</td>
<td>Trichloroethylene</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>48.</td>
<td>Xylene</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>49.</td>
<td>Zinc Chloride, Saturated</td>
<td>B</td>
<td>0</td>
</tr>
</tbody>
</table>

3. **Hot Water Test**
   
a. Test Procedure: 190 to 205 degrees Fahrenheit (88°C to 96°C) hot water shall be allowed to trickle (with a steady stream and at a rate of not less than 6 ounces (177.5 cc) per minute) on the finished surface, which shall be set at an angle of 45°, for a period of 5 minutes.
   
b. Acceptance Level: After cooling and wiping dry, the finish shall show no visible effect from the hot water.

4. **Paint Adhesion on Steel Test**
   
a. Test Procedure: Test shall be based on ASTM D2197-86 “Standard Method of Test for Adhesion of Organic Coating.” Two sets of eleven parallel lines 1/16 inch (1.587 mm) apart shall be cut with a razor blade to intersect at right angles thus forming a grid to 100 squares. The cuts shall be made just deep enough to go through the coating, but not into the substrate. Brush surface lightly with a soft brush for one minute. Examine under 100 fc (1076 lux) of illumination.
   
b. Acceptance Level: Ninety or more of the squares shall show finish intact.

5. **Impact Test**
   
a. Test Procedure: Drop a 1 pound (0.4536 kg) ball (approximately 2 inch (50.8 mm) diameter from a distance of 12 inches (305 mm) onto a flat horizontal surface, coated to manufacturer’s standard manufacturing method.
   
b. Acceptance Level: No visual evidence to the naked eye of cracks in the finish due to impact.

6. **Paint Hardness on Steel Test**
   
a. Test Procedure: Paint film shall be tested with pencils of various hardnesses. Pencils shall have a wide, sharp edge. Pencils shall be pushed across surface in a chisel-like manner.
   
b. Acceptance Level: Finish film shall not rupture from a sharpened 4H pencil.

### 2.3 CABINET HARDWARE

**A. General:** Special cabinets, such as corrosives storage, flammable liquid and solvent storage, rock storage, map storage, museum storage, radioisotope storage, and narcotics lockers, may be provided with the manufacturer’s standard hardware.

1. All door and drawer pulls shall match, regardless of type of casework, except for:
   
a. Flammable liquid/ solvent storage cabinets, which should use manufacturer’s standard latch handles as required to satisfy requirements of regulatory approvals.

2. All hardware shall be compliant with the ADA Standards for Accessible Design (28 CFR Part 36).

**B. Drawer and Hinged Door Pulls:**

1. Drawer and door pulls shall attach to door or drawer with machine screws. Two (2) pulls shall be furnished on drawers wider than 28 inches (711 mm). Plastic pulls or other types subject to breakage are not acceptable.

2. Type: Pulls shall be round “wire.”
a. **Material and Finish:**
   1. Stainless steel with finish as follows:

b. **Size:**
   1. Length: 4 inches (100 mm) center to center of screw holes.
   2. Diameter: ¼ inch (6 mm).

C. **Hinges:**
   1. General: Hinges shall be attached to both door and case with three screws through each leaf. Provide two hinges for doors up to 48 inches (1219 mm) high; three hinges for doors over 48 inches (1219 mm) high.
   2. Type: Institutional with a five-knuckle bullet-type barrel. Characteristics:
      a. Height: 2½ inches (63 mm), nominal.
      b. Material: Stainless steel with stainless steel screws.
         1. Finish:
            b). BHMA 629 Bright (Previously US32).

      2. Manufacturers:
         b). Approved substitution.

D. **Shelf Hardware:**
   1. Shelf Supports:
      a. Adjustable shelf supports: Adjustable clear plastic shelf support with lockdown clips.

      2. Manufacturers:
         a). Bainbridge Manufacturing, Inc., P. O. Box 487, 237 W 3rd, Waterville, WA 98858 Tel: 800 255-4702.
         b). The Engineered Products Company (Epco), P. O. Box 108, Flint, MI 48501 Tel: 313 767-2050.
         c). Knape & Vogt Manufacturing CO., 2700 Oak Industrial Dr. NE, Grand Rapids, MI 49505 Tel: 616 459-7620.
         d). Sugatsune America, Inc. 221 East Selandia Lane, Carson, CA 90746 Tel: 310 329-6373.
         e). Approved substitution.

E. **Catches:**
   1. Roller Catches:
      a. Types and Materials: Roller catches shall be one of the following types. All-plastic or knuckle-type catches are not acceptable, except at corrosive storage cabinets.
         1). Tension ball catches consisting of a case with an adjustable-tension ball catch and a matching strike. Components shall be either stainless steel, chrome plated zinc alloy, or chrome-plated brass.
         2). Nylon roller housed in a steel case, which catches on a steel strike plate. Steel components shall be zinc finished.
3). At metal casework base cupboards, catches may consist of a two-piece heavy-duty cam action positive catch positioned near the pivoting edge of door which provides a clean unobstructed opening. Main body of the catch shall be confined within an integral cabinet divider rail, while latching post shall be mounted on the hinge side of door.

4). At corrosive storage cabinets, catches shall be non-metallic.

b. Application: Provide roller catches at all cabinet doors without elbow catches or as indicated.

1). Unless otherwise indicated, at wall and base cabinets, locate roller catches at top of door.

2). Unless otherwise indicated, at tall cabinets, locate roller catches at fixed center shelf.

c. Manufacturers:

1). The Engineered Products Company (Epco), P. O. Box 108, Flint, MI 48501 Tel: 313 767-2050.

2). Sugatsune America, Inc. 221 East Selandia Lane, Carson, CA 90746 Tel: 310 329-6373.

3). Approved substitution.

2. Elbow catches: Heavy-duty, adjustable, spring-type elbow catch and strike plate.

a. Material: Brass or steel with bright chromium plated finish.

b. Application: Elbow catches shall be used on left hand doors of locked double door cabinets, including tall cabinets.

1). At tall cabinets, elbow catch shall latch to fixed center shelf. Latching devices using chains or strings are not acceptable.

c. Manufacturers:

1). The Engineered Products Company (Epco), P. O. Box 108, Flint, MI 48501 Tel: 313 767-2050.

2). Approved substitution.

F. Drawer slides:

1. Typical: Ball bearing slides:

a. Material:

1). Clear, zinc-coated steel.

b. Full extension, 100 lb/pr. (45 kg/pr.) capacity: Accuride 3832, Fulterer FR5000, or equal.

c. File drawers shall be equipped with rail mounted overtravel, 150 lb/pr. (68 kg/pr.) capacity: Accuride 4034, Fulterer 5755, or equal.

d. Keyboard shelves or trays: 3/4 extension 75 lb/pr. (34 kg/pr.) capacity keyboard shelf slide. Product: Accuride 2009, or equal.


f. Manufacturers:

1). Accuride, 12311 Shoemaker Ave., Santa Fe Springs, CA 90670 Tel: 562 903-0200.

2). Hettich America LLP, 6225 Shiloh Road, Alpharetta, Georgia 30005 Tel: 770 887-3733.

3). Fulterer USA, 542 Townsend Ave., High Point, NC 27263 Tel: 800 395-4646.
4). Waterloo Furniture Components Inc., 501 Manitou Dr., Kitchener, Ontario, Canada N2C 1L2 Tel: 519 748-5060.

5). Approved substitution.

G. Drawer Stops: All regular drawers shall be equipped with integral stops to prevent drawer head impact with cabinet body.

H. Door Stops: Provide door stops for any cabinet door, which will strike an obstruction when opened between 90 and 135 degrees.

1. Stop to be either:
   a. Sash chain, No. 30 zinc-plated steel.
      1). Terminations: Zinc chromate wire screw eyes. Open eye as required to attach stop with screws. Through-bolting not allowed.
   b. Coated cable.
      1). Seven-strand, 7-wire-per-strand, stainless steel cable with clear nylon coating.
      2). Wire diameter: 0.047 inches.
      3). Composite diameter with coating: 0.063 inches.
      4). Terminations: Number 10 stake eye on both ends. Attach to door/cabinet with screws. Through-bolting not allowed.
      5). McMaster Carr part number 30345T3 or equivalent.

2. Engineer stop to length to allow door to open 1 ½ inch (40 mm) from obstruction.

I. Number Plates: Provide 5/8 inch (16 mm) by 1 ¼ inches (32 mm) aluminum number plates with black numbers, pinned in place. Stick-on holders not acceptable. Number plates shall be provided at all drawers where indicated on the plans. Number drawers sequentially in each laboratory.

J. Locks:

1. General: Provide locks on all file cabinet drawers. Provide locks at other locations as indicated on the drawings.

2. Lock type: Deadbolt-type lock.
   a. Disc-tumbler-type locks and/or cam-type locks will not be accepted.
   b. Framed sliding door locks shall be plunger type.
   c. Refer to Elbow Catches section, above, for requirements at two-swinging-door cabinets.

3. Testing requirements:
   a. Locks shall comply with ANSI/BHMA standard E07121.
   b. Lock shall be cycle tested per ANSI/BHMA A156.11 Grade 1.

4. Include spacers, adapters, fasteners, and strikes.
   a. All locks shall strike into metal material. Striking directly into wood is not acceptable.

5. Barrel length shall be coordinated with specific conditions.

6. Finish: Locks shall have satin nickel or satin chrome finish.

7. Keying:
   a. Key quantities: Provide two keys per lock. Provide four copies of any master/ grand master keys.
b. Key system:
   1). Key system shall support a minimum of 2000 different keys.
   2). Key system shall support up to three levels of master keys (grand-master keys, master keys, and sub-master keys) in addition to individual keys.

c. Key cylinder type:
   1). Coordinate key type with owner.

d. Key schedule: Refer to drawings and coordinate key schedule with Owner.

8. Key engraving:
   a. Keys to be engraved with an identification number corresponding to the layout of unique keys on the project. All identical keys shall be engraved with the same number.
   b. At laboratories with multiple, individually-locked drawers where number plates are indicated, engrave each key with number to match the number plate on each drawer.

9. Manufacturers:
   a. Swinging Doors and Drawers:
      1). Illinois Lock Company, 301 West Hintz Rd., Wheeling, IL 60090 Tel: 847 537-1800.
      2). National Cabinet Lock, 200 Old Mill Rd., P. O. Box 200, Mauldin, South Carolina 29662 Tel: 864 297-6655.
      4). Approved substitution.

K. Padlock Hasps: Provide one of the following:
   1. Stainless steel padlock-eye cam-type locking device and strike plate at cabinet locations as indicated on the drawings. Strike plate, or protection plate, shall be large enough to prevent padlock from damaging door or drawer front.
   2. Barrel-style cam-type padlock hasp sized to fit standard lock cylinder hole with finish to match drawer pulls, and strike plate at cabinet locations as indicated on the drawings. Strike plate, or protection plate, shall be large enough to prevent padlock from damaging door or drawer front.
   3. Cam-lock shall engage or strike into a metal casting.
   4. Manufacturers:
      a. Northeast Lock Corporation, 48 Oak St., Clifton, NJ 07014 Tel: 800 524-2575.
      d. Approved substitution.
   5. Provide 15% (Fifteen Percent) of total quantity of complete padlock hasp assemblies as additional spare parts, bagged, boxed, and clearly labeled.

L. Glides: Non-marring material, 1 inch (25 mm) diameter, minimum, with at least 5/8 (16 mm) vertical adjustment. Provide on movable tables, unless otherwise indicated.

M. Leveling devices: Provide each table leg with 3/8 inch (10 mm) minimum diameter leveling bolt and floor clip.
N. Leg shoes: Leg shoes shall be provided on all legs and table legs to conceal leveling devices, except for tables with casters. Shoes shall be 2 ½ (63 mm) inch high and of black rubber or pliable black vinyl material. Use of a leg shoe which does not conceal leveling device is not acceptable.

O. Floor clips: Provide leg assemblies and fixed table legs with floor clips securely fastened to the floor after shimming.

P. Casters: Where indicated on Laboratory Furnishing drawings, provide sets of 3 ½ inch (89 mm) diameter wheels with self-lubricating bearing, rated to carry 250 pounds (113 kg) minimum each. Each caster must swivel and have a locking brake. Wheel shall be of molded polyurethane tread mechanically locked to a polyolefin core.

1. Material: Caster shall be heavy gauge cold rolled steel with bright zinc plating.
2. Manufacturers:
   a. Acorn Industrial Products Co., 7 Union Hill Dr., W. Conshohocken, PA 19428 Tel: 800 523-5474.
   b. Caster Technology Corporation, 3265 Whipple Rd., Union City, CA 94587, Tel: 510 429-6727.
   d. Approved substitution.

Q. Support Struts and Service Ledging: Refer to specifications for slotted channel framing in this Section.

2.4 LABORATORY WORK SURFACES

A. Epoxy Resin:

1. Manufacturers: Products complying with this specification may be provided by the following manufacturers.
   b. Durcon Laboratory Tops, Inc., 206 Allison Drive, Taylor, TX 76574 Tel: 512 595-8000.
   c. Kewaunee Scientific Corporation, P O Box 1842, Statesville, NC 28687 Tel: 704 873-7202.
   d. Approved substitution.

2. Thickness:
   a. Typical work surface: 1 inch (25 mm).
   b. Fume hood work surfaces: Tops shall be 1¼ (32 mm) inches thick at outer edge, indented minimum ¼ inch (6 mm) to provide a raised rim around all exposed edges 1 inch (25 mm) wide, minimum, or as to allow for the fume hood sash. The front top edge of the raised rim and exposed vertical corners of the top shall be rounded or chamfered to a 1/8 inch (3 mm) radius. The juncture between the raised rim and the top surface shall be coved or chamfered to a ¼ inch (6 mm) radius.
   c. Curbs and Splashes: ¾ inch (19 mm).

3. Color:
   a. Base Bid: Black
b. Add Alternative Bid: Graphite as manufactured by Durcon Laboratory Tops, Inc., or approved substitution.

c. Color sample to be approved by Architect before work is put in hand.

4. Description:

a. Monolithic filled epoxy resin work surface consisting of a polymerized cast resin material oven-cured in molds.

b. Drip Grooves: Provide under all work surface exposed edges, unless noted otherwise on the Laboratory Furnishing Drawings. Drip grooves shall be ½ inch (13 mm) from the front edge where the top overhangs 1 inch (25 mm) and ¼ inch (6 mm) from the edge where the edge overhangs ½ inch (13 mm).

c. Edge profile: For all exposed upper edges and corners:

1) Bevel eased: 1/8 inch (3 mm) machined bevel with blended radius corners.

d. Sink Mounting:

1) Drop-in Sink Cutouts: Cutouts shall be profiled to provide support for the sink, and to ensure that the rim of the installed sink is 1/8 inch (3 mm) below the surrounding work surface level or bottom of drain grooves, if present. The top edge of the cutout shall have 1/8 inch (3 mm) bevel. Ensure that there shall be no gaps between the installed sink rim and work surface.

e. Curbs and Splashes:

1) Height: 4 inches (100 mm), unless noted otherwise on Laboratory Furnishing Drawings.

2) Bonded to the surface of the top to form a square joint.

f. Provide all holes and cutouts as required for built-in equipment and mechanical and electrical service fixtures. Verify size of opening with actual size of equipment to be used prior to making openings. Form inside corners to a radius of not less than 1/8 inch (3 mm). After sawing, rout and file cutouts to ensure smooth, crack-free edges. Seal exposed edges after cutting with a waterproofing material recommended by the manufacturer.

g. Provide full-length, one-piece tops and backsplashes wherever possible, and keep field joints to an absolute minimum.

5. Physical Properties:

a. Chemical resistance:

1) Organic solvents: A cotton ball, saturated with the test chemical, is placed in a one ounce bottle with a reservoir of liquid above the ball. The container is inverted on the test material surface for a period of 24 hours. Test temperature: 23°C ±2°C.

2) Other test chemicals: Five drops (1/4 cc) of the test chemical are placed on the test material surface. The chemical is covered with a 1 inch diameter watch glass for a period of 24 hours. Test temperature: 23°C ±2°C.

3) Evaluation: After 24 hours exposure, exposed areas are washed with water, then a detergent solution, finally with naphtha, then rinsed with distilled water, dried with a cloth, and rated as follows:

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No effect No detectable change in the material surface.</td>
</tr>
<tr>
<td>1</td>
<td>Excellent Slight detectable change in color or gloss but no change in function or life of the surface.</td>
</tr>
</tbody>
</table>
2. Good: A clearly discernable change in color or gloss but no significant impairment of surface life or function.

3. Fair: Objectionable change in appearance due to discoloration or etch, possibly resulting in deterioration of function over an extended period of time.

4. Failure: Pitting, cratering, or erosion of the surface. Obvious and significant deterioration.

4). Test results:

<table>
<thead>
<tr>
<th>Test chemical</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>Black</td>
</tr>
<tr>
<td>Dark gray</td>
<td>Light gray</td>
</tr>
<tr>
<td>Light gray</td>
<td>Beige</td>
</tr>
<tr>
<td>Chromium acid</td>
<td>40% 3 2 2 2</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>10% 0 0 0 0</td>
</tr>
<tr>
<td>Hydrochloric acid (conc.)</td>
<td>37% 0 0 0 0</td>
</tr>
<tr>
<td>Nitric acid</td>
<td>40% 0 0 0 0</td>
</tr>
<tr>
<td>Nitric acid (conc.)</td>
<td>70% 0 0 0 0</td>
</tr>
<tr>
<td>Sulfuric acid</td>
<td>60% 0 0 0 0</td>
</tr>
<tr>
<td>Sulfuric acid (conc.)</td>
<td>96% 4 4 4 4</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>5% 0 0 0 0</td>
</tr>
<tr>
<td>Acetic acid (glacial)</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Citric acid</td>
<td>1% 0 0 0 0</td>
</tr>
<tr>
<td>Oleic acid</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Phenol solution</td>
<td>5% 0 0 0 0</td>
</tr>
<tr>
<td>Ammonium hydroxide</td>
<td>10% 0 0 0 0</td>
</tr>
<tr>
<td>Sodium carbonate sol.</td>
<td>20% 0 0 0 0</td>
</tr>
<tr>
<td>Sodium hydroxide sol.</td>
<td>60% 0 0 0 0</td>
</tr>
<tr>
<td>Sodium hypochlorite sol.</td>
<td>4% 0 0 0 0</td>
</tr>
<tr>
<td>Acetone</td>
<td>1 1 1 1 1</td>
</tr>
<tr>
<td>Benzene</td>
<td>1 1 1 1 1</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>1 1 0 0 0</td>
</tr>
<tr>
<td>Diethyl ether</td>
<td>0 0 1 1 1</td>
</tr>
<tr>
<td>Dimethyl formamide</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>0 1 1 1 0</td>
</tr>
<tr>
<td>Ethyl alcohol</td>
<td>95% 0 0 0 0</td>
</tr>
<tr>
<td>Ethylene dichloride</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Heptane</td>
<td>0 0 1 1 0</td>
</tr>
<tr>
<td>Isooctane</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Kerosene</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Methyl alcohol</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Toluene</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Aniline</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Mineral oil</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Olive oil</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Soap solution</td>
<td>1% 0 0 0 0</td>
</tr>
<tr>
<td>Transformer oil</td>
<td>0 0 0 0 0</td>
</tr>
<tr>
<td>Turpentine</td>
<td>0 0 0 0 0</td>
</tr>
</tbody>
</table>

b. Heat resistance:
1). High temperature test: A porcelain crucible is heated to a dull red color, placed on the test material, and allowed to cool to ambient temperature. Result: No observable surface deformation.

2). Flame test: A 3/8 inch (10 mm) Bunsen burner is adjusted to a quiet flame with a 1 1/2 inch (38 mm) inner cone, overturned on the test material, and allowed to stay for 5 minutes. Result: no observable surface deformation.

c. Physical properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>Standard</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive strength</td>
<td>ASTM D695</td>
<td>31,400 psi (216 MPa)</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>ASTM D638</td>
<td>8,000 psi (55 MPa)</td>
</tr>
<tr>
<td>Flexural strength</td>
<td>ASTM D790</td>
<td>11,700 psi (81 MPa)</td>
</tr>
<tr>
<td>Rockwell hardness “M”</td>
<td>ASTM D785</td>
<td>105-110</td>
</tr>
<tr>
<td>Specific density</td>
<td>ASTM D792</td>
<td>122.4 lb/ft³ (1960 kg/m³)</td>
</tr>
<tr>
<td>Water absorption</td>
<td>ASTM D570</td>
<td>0.01%</td>
</tr>
<tr>
<td>Fire Resistance</td>
<td>ASTM D635</td>
<td>ATB (sec)=0</td>
</tr>
<tr>
<td>Heat deflection @ 264 psi</td>
<td>ASTM D648</td>
<td>205°F (172°C)</td>
</tr>
</tbody>
</table>

B. Static Dissipative High-Pressure Plastic Laminate Tops:

1. Manufacturers: Products complying with this specification may be provided by the following manufacturers.
   a. Nevamar Decorative Surfaces, 8339 Telegraph Road, Odenton MD 21113
      Tel: 410 551-5000.
   b. Pionite Decorative Surfaces, One Pionite Road, Auburn, ME 04211 Tel: 800 746-6483.
   c. Approved substitution.

2. Type: Static dissipative laminate work surface and electrical grounding system installed to minimize the risk of static electricity damage to sensitive devices.

3. Substrate Thickness:
   a. Typical work surface: 1 inch (25 mm).
   b. Curbs and Splashes: ¾ inch (19 mm).

4. Color: To be selected by Architect.

5. Description:
   a. High-pressure decorative laminate consisting of a resin formulation applied over the decorative surface paper. The decorative paper shall be treated with melamine resin, and the core shall consist of kraft papers impregnated with phenolic resin. Sheets shall be bonded under high temperature and pressure. Horizontal post-forming grade static dissipative plastic laminate sheet to NEMA LD 3-1995.
   b. Finish: Fine beaded “crystal” texture to minimize smudges and finger marks, and to provide optimum scratch resistance.
   c. Core material: Hardwood veneer-core plywood.
      1). Description: A one step calibrated core +/- 0.5mm (to avoid voids) with type 1 waterproof nauf glue. Grade 2 face, and back of mill choice plywood veneer.
      2). Thickness/Plies:
         a). ¾ inch (19 mm): minimum 7-ply.
         b). 1 inch (25 mm): minimum 9-ply.
      3). Physical Properties:
         a). Average modulus of rupture: 7346 psi (50.65 N/mm²).
b. Face Screw Holding Strength: 355 lbf (1579 N).

d. Backing sheets: High-pressure phenolic meeting or exceeding NEMA Standard LD3-2005 Grade BKL.

e. Plastic laminate adhesive: High-pressure decorative laminate shall be bonded to core with thermosetting resorcinol or phenol-resorcinol adhesive, or as recommended by the manufacturer for the application, at temperature above 65 degrees Fahrenheit (18°C) at a pressure no less than 15 pounds per square inch (103 kPa). Laminate core is not to exceed 10% moisture content and is to be laminated and cured in a controlled environment between 45% and 60% RH.

f. Edging: Tops shall be edged with 3 mm PVC edge banding set in hot melt adhesive. Adhesive shall have a minimum softening point of 150 degrees Fahrenheit (65°C). Apply primer to substrate when recommended by adhesive manufacturer.

g. Flush mount insert grounding system: The work surface installation shall be provided with effective electrical grounding to ensure the safe dissipation of static electricity to ground. Coordinate with Division 26. Connection to the work surface laminate shall be of the flush surface. Projecting connectors and exposed terminals will not be accepted. Components shall include flat socket cap screw to secure brass insert, knurled brass insert to provide electrical connection, flat washer to provide flat surface for securing ring terminals, ring terminal to connect wire to flush mount insert, and nut to fasten flush mount insert together.

h. Personnel grounding system: Provide dual banana jack terminals, 10 feet (3 m) of 22 gauge wire, and 2 banana plug connections in front of work surface grounded to the flush mount insert system.


j. Electrical performance:

1). Point to point resistance (per EOS/ESD–S4.1):
   2). 60% to 40% RH: $10^6$ to $10^7$ ohms.
   3). 40% to 20% RH: $10^7$ to $10^8$ ohms.
   4). 20% to 10% RH: $10^8$ to $10^9$ ohms.

5). Point to ground resistance (per EOS/ESD–S4.1):
   6). 60% to 40% RH: $10^6$ to $10^7$ ohms.
   7). 40% to 20% RH: $10^7$ to $10^8$ ohms.
   8). 20% to 10% RH: $10^8$ to $10^9$ ohms.

9). Volume resistance (measured face to back at 72°F (22.2°C), 100V with a LCD Megohmmeter, Item No. 19770, NFPA Electrodes (2.5 inch (63 mm) diameter, 5 lb (2.27 kg)):
   10). 60% to 30% RH: $10^6$ to $10^8$ ohms.
   11). 30% to 10% RH: $10^8$ to $10^9$ ohms.

12). Static Decay (FTMS 101C, Method 4046 test):
   13). 50% RH: 0.01 sec.
   14). 10% RH: 0.02 sec.

k. Provide all holes and cutouts as required for built-in equipment and mechanical and electrical service fixtures. Verify size of opening with actual size of equipment to be used prior to making openings. Form inside corners to a radius of not less than 1/8 inch (3 mm). After sawing, rout and file cutouts to ensure smooth, crack-free edges.

l. Provide full-length, one-piece tops and backsplashes wherever possible, and keep field joints to an absolute minimum.

m. Curbs and Splashes:

1). Height: 4 inches (100 mm), unless noted otherwise on Laboratory Furnishing Drawings.
2). Fabricate similar to top with PVC edge band along exposed ends.
3). Splash shall be set in a thin bead of silicone sealant to prevent moisture migration through the joint.

n. Physical Properties:

2). Minimum Thickness: 0.036 inches ± 0.005 inches (0.9 mm ± 0.08 mm).
3). Cleanability: 5 cycles (NEMA LD3 test method 3.4).
4). Boiling Water Resistance: Moderate effect (NEMA LD3 test method 3.5).
6). Ball Impact Resistance: 35 inches (889 mm) (NEMA LD3 test method 3.8).
8). Dimensional change:
9). Machine direction: 0.40% (NEMA LD3 test method 3.11).
10). Cross direction: 0.80% (NEMA LD3 test method 3.11).
12). Appearance: No ABC defects.
15). Stain Resistance Performance Test Results: The surface shall show essentially no effect on Black (Lab grade) plastic laminate when left in contact for 16 hours either when reagents were kept covered or allowed to evaporate.

<table>
<thead>
<tr>
<th>Stain</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td>1</td>
</tr>
<tr>
<td>50%/50% Ethyl alcohol</td>
<td>1</td>
</tr>
<tr>
<td>Acetone</td>
<td>1</td>
</tr>
<tr>
<td>Household ammonia</td>
<td>1</td>
</tr>
<tr>
<td>10% Citric acid</td>
<td>1</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>1</td>
</tr>
<tr>
<td>Fresh coffee</td>
<td>1</td>
</tr>
<tr>
<td>Fresh tea</td>
<td>1</td>
</tr>
<tr>
<td>Catsup</td>
<td>1</td>
</tr>
<tr>
<td>Yellow mustard</td>
<td>1</td>
</tr>
<tr>
<td>10% Povidone iodine</td>
<td>1</td>
</tr>
<tr>
<td>Black permanent marker</td>
<td>1</td>
</tr>
<tr>
<td>No. 2 pencil</td>
<td>1</td>
</tr>
<tr>
<td>Wax crayon</td>
<td>1</td>
</tr>
</tbody>
</table>
C. Stainless Steel: Refer to Stainless Steel Fabrications section of this specification.

D. Solid Laminated Wood Tops:
   1. Edge grain maple laminations with edge grain exposed.
   2. Thickness:
      a. 1¾ inch (44 mm)
   3. Composed of solid hard maple strips 1¾ inches (44 mm) wide, glued with water-resistant resin under heavy pressure side to side and end to end.
   4. Curbs and splashes to be ¾ inch (18mm) thick matching material, 4 inches (100mm) high.
   5. Round top edges and corners. Plane and sand smooth all surfaces.
   6. Provide full-length, one-piece tops and backsplashes wherever possible, and keep field joints to an absolute minimum.
   7. Finish:
      a. Finish with three coats of moisture and chemical resistant varnish coating applied to all surfaces and edges. Fine sand between coats.
   8. Manufacturers:
      a. Bally Block Co., P.O. Box 188, Bally, Pennsylvania 19503.
      b. Michigan Maple Block Co., P.O. Box 245, Petoskey, Michigan 49770.
      c. Approved equal.

2.5 ELECTRONICS BENCH

A. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.
   1. Edsal Manufacturing Company, Inc., 4400 South Packers Avenue, Chicago, IL 60609 Tel: 773 254-0600.
   2. Production Basics, Inc., 31 Dunham Road, Billerica, MA 01821 Tel: 617 926-8100.
   3. Tennsco, P.O. Box 1888, Dickson, TN 37056-1888 Tel: 800 251-8184.
   4. Workstation Industries, 1938 E. Pomona Street, Santa Ana, CA 92705 Tel: 714 258-7535.
   5. Approved substitution.

B. Electronics Bench: Provide heavy duty, steel frame bench as detailed on the Laboratory Furnishing drawings. Basis of design models:
   1. Edsal Manufacturing Electronic Tech Bench.
   2. Production Basics RTW Table.
   3. Tennsco Technical Workstation.

C. Characteristics:
   1. Dimensions: As indicated on the Laboratory Furnishing drawings.
   2. Materials: Table structure constructed of minimum 16 gauge steel.
      a. Finish: Electrostatically applied epoxy powder coating.
      b. Color: As selected by the Architect.
3. Adjustable Height Legs: Worksurface shall be adjustable in height in 1 inch increments from 30 inches to 36 inches.
5. Upper Shelf: 1-1/4 inch-thick, electro-static-dissipative (ESD) plastic laminate on industrial-grade particleboard core, supported by risers units at each side, or legs at each corner.
6. Load Capacity of Worksurface and Shelf: 40 pounds per square foot.
7. Electrical:
   a. Provide a minimum of (8) 120 V duplex outlets below the shelf and not obstructing the work surface. Outlets can be on the riser units, or within an integrated raceway directly below the upper shelf.
   b. Provide master on/off switch.
   c. Provide a 96 inch long minimum power cord with NEMA 5-20 plug.
   d. Provide ground wire for each ESD surface.

2.6 SHELVING ASSEMBLIES

A. High-Pressure Decorative (Plastic) Laminate Shelving:
1. Manufacturers/Facing material: Products complying with this specification may be provided by the following manufacturers.
   a. Nevamar Decorative Surfaces, One Nevamar Place, Hampton, SC 29924 Tel: 800 638-4380.
   b. Pionite Decorative Surfaces, One Pionite Road, P.O. Box 1014, Auburn, ME 04211 Tel: 800 746-6483.
   c. Wilsonart International, 2400 Wilson Place, P. O. Box 6110, Temple, TX 76503 Tel: 800 433-3222.
   d. Approved substitution (no known equal).
2. Approved Products:
   b. Pionite ChemGuard.
   c. Wilsonart ChemSurf
3. Color: To be selected by Architect.
4. Description:
   a. High-pressure decorative laminate, meeting or exceeding NEMA Standard LD3 2005 Grade HGP, HGL, or HGS requirements, consisting of a resin formulation applied over the decorative surface paper to achieve chemical resistance. The decorative paper shall be treated with melamine resin, and the core shall consist of kraft papers impregnated with phenolic resin. Sheets shall be bonded under high temperature and pressure. Product shall be developed for casework, work surface, and shelving surfaces in laboratories.
   b. Laminate shall be applied to top and bottom surfaces.
   c. Finish: Fine pebble-grained “crystal” texture or matte texture with slight sheen to minimize smudges and finger marks, and to provide optimum scratch resistance.
      1). Gloss: 15-16 +/- 3 gloss units.
   d. Physical Properties:
      2). Minimum Thickness: 0.038 inches ± 0.005 inches (0.97 mm ± 0.13 mm).
3). Cleanability: 10 cycles (NEMA LD3 test method 3.4).
4). Boiling Water Resistance: No effect (NEMA LD3 test method 3.5).
7). Ball Impact Resistance: 60 inches (1524 mm) (NEMA LD3 test method 3.8).
9). Dimensional change:
10). Machine direction: 0.50% (NEMA LD3 test method 3.11).
11). Cross direction: 0.80% (NEMA LD3 test method 3.11).
12). Wear resistance: 1,500 cycles, min. (black); 700 cycles, min. (other colors) (NEMA LD3 test method 3.13).
14). Stain Resistance Performance Test Results: The surface shall show essentially no effect on Black (Lab grade) plastic laminate when left in contact for 16 hours either when reagents were kept covered or allowed to evaporate.

| 0 | No effect | No detectable change in the material surface. |
| 1 | Excellent | Slight detectable change in color or gloss but no change in function or life of the surface. |
| 2 | Good | A clearly discernable change in color or gloss but no significant impairment of surface life or function. |
| 3 | Fair | Objectionable change in appearance due to discoloration or etch, possibly resulting in deterioration of function over an extended period of time. |
| 4 | Failure | Pitting, cratering, or erosion of the surface. Obvious and significant deterioration. |

**Acids**

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic acid</td>
<td>All 0</td>
</tr>
<tr>
<td>Aqua regia</td>
<td>0</td>
</tr>
<tr>
<td>Chromic trioxide (Chromic acid cleaning solution)</td>
<td>1</td>
</tr>
<tr>
<td>Glacial acetic acid</td>
<td>99% 0</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>All 0</td>
</tr>
<tr>
<td>Hydrofluoric acid</td>
<td>48% 0</td>
</tr>
<tr>
<td>Formic acid</td>
<td>All 0</td>
</tr>
<tr>
<td>Nitric acid</td>
<td>All 3</td>
</tr>
<tr>
<td>Sulfuric acid</td>
<td>All 0</td>
</tr>
<tr>
<td>Perchloric acid (concentrated)</td>
<td>0</td>
</tr>
<tr>
<td>Phosphoric acid</td>
<td>All 0</td>
</tr>
<tr>
<td>Picric acid</td>
<td>1.2% 0</td>
</tr>
<tr>
<td>Tannic acid (saturated)</td>
<td>0</td>
</tr>
<tr>
<td>Uric acid (saturated)</td>
<td>0</td>
</tr>
<tr>
<td>Alkalis</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Ammonium hydroxide</td>
<td>All</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>All</td>
</tr>
<tr>
<td>Sodium sulfide</td>
<td>15%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solvents</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Amyl acetate</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Amyl alcohol</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Butyl alcohol</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Chloroform</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Cresol</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Dimethylformamide</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Dioxane</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>EDTA</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Ethyl alcohol</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Methanol</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Methyl ethyl ketone</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Methylene chloride</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>n-Hexane</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Naphthalene</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Phenol</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Tetrahydrofuran</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Toluene</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Trichlorethane</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Xylene</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General Reagents</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alconox (lab detergent)</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Aluminon</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Ammonium phosphate</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Aromatic ammonia</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Benedicts solution</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Calcium hypochlorite (concentrated)</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Camphorated parachlorophenol</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Cellosolve</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Copper sulfate</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Ethylene glycol</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Eucalyptol</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Formalin</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Gasoline</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>3%</td>
<td>0</td>
</tr>
<tr>
<td>Iodine</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Karl Fisher Reagent</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Kerosene</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Lactated ringers</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Lysol</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>General Reagents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Methyl methacrylate</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Mineral Oil</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Monsel’s solution (Ferric subsulfate)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Naphtha</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Petroleum jelly</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Phosphate buffered saline (PBS)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pine oil</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Potassium permanganate</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Povidone iodine</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Procaine</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Quaternary ammonia compounds</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Silver nitrate</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Sodium azide</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Sodium chromate</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Sodium hypochlorite</td>
<td>5%</td>
<td>0</td>
</tr>
<tr>
<td>Sodium thiocyanate</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>50%</td>
<td>0</td>
</tr>
<tr>
<td>Thymol &amp; Alcohol</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Tincture of Iodine</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Tincture of Mercurochrome</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Tincture of Merthiolate</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Trisodium phosphate</td>
<td>30%</td>
<td>0</td>
</tr>
<tr>
<td>Urea</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Vegetable oils</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Zephran chloride</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Zinc chloride</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Zinc oxide ointment</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stains and Indicators</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag Eosin Bluish 5% in Alcohol</td>
<td>0</td>
</tr>
<tr>
<td>Bromothymol Blue</td>
<td>0</td>
</tr>
<tr>
<td>Cresol Red</td>
<td>0</td>
</tr>
<tr>
<td>Crystal Violet</td>
<td>0</td>
</tr>
<tr>
<td>Gentian Violet</td>
<td>1%</td>
</tr>
<tr>
<td>Gram Stains</td>
<td>0</td>
</tr>
<tr>
<td>Malachite Green</td>
<td>0</td>
</tr>
<tr>
<td>Methyl Orange</td>
<td>0</td>
</tr>
<tr>
<td>Methyl Red</td>
<td>0</td>
</tr>
<tr>
<td>Methylene Blue</td>
<td>0</td>
</tr>
<tr>
<td>Nigrosine</td>
<td>0</td>
</tr>
<tr>
<td>Safranin O</td>
<td>0</td>
</tr>
<tr>
<td>Sudan III</td>
<td>0</td>
</tr>
<tr>
<td>Thymol Blue</td>
<td>0</td>
</tr>
<tr>
<td>Wright's Blood Stain</td>
<td>0</td>
</tr>
</tbody>
</table>

5. Plastic laminate adhesive: High-pressure decorative laminate shall be bonded to core with thermosetting resorcinol or phenol-resorcinol adhesive, or as recommended by the manufacturer for the application, at temperature above 65°F (18.3°C) at a pressure no less than 15 pounds per square inch. Laminate core is not to exceed 10% moisture content and is to be laminated and cured in a controlled environment between 45% and 60% RH.

6. Core material: Hardwood Veneer Plywood.
a. Description: A one step calibrated core +/- .5mm (to avoid voids) with type 1 waterproof nauf glue. Grade 2 face, and back of mill choice plywood veneer.

b. Thickness/Plies:
   1) 1 inch (25 mm): minimum 9-ply.

c. Physical Properties:
   1) Average modulus of rupture: 7346 psi (50.65 N/mm²).
   2) Face Screw Holding Strength: 355 lbf (1579 N).

7. Edging:
   a. Unless otherwise indicated, all edges shall be edgebanded with 3 mm PVC edge banding set in hot melt adhesive. Adhesive shall have a minimum softening point of 150°F (65.6°C). Apply primer to substrate when recommended by adhesive manufacturer. Contact cement is not acceptable. Color of edgebanding to be selected by the Architect.

B. Safety Edges:
   1. Types:
      a. Retainer Rail: ¼ inch (6 mm) diameter stainless steel retainer rail, as indicated on the drawings.
   2. Refer to the description of each system below for locations of each type.

C. Reagent Shelves on adjustable shelf standards with a steel tube support system.
   1. Shelving: High-Pressure Decorative Laminate shelving as specified above.
   2. Steel Frame Support System: Provide cold rolled steel tube vertical and horizontal support members with radiused edges. All members shall be welded together. Grind all welds smooth and polish to produce clean smooth appearance with no visual evidence of welds after paint is applied. All vertical members shall be one piece continuous from floor to underside of structure above or to top horizontal member as indicated on the drawings. Horizontal top and intermediate members shall be one piece between vertical members. Provide welded caps at all open ends of tube sections. Secure vertical members to floor slab, underside of benchtop, if indicated on the drawings, and to underside of structure above.
      a. Tube steel dimensions:
         1) 2 inches x 2 inches, 12 gauge (50 x 50 x 2.8 mm).
   3. Shelf standards:
      a. Steel tubes shall be punched to receive adjustable shelf brackets. Pattern shall match Knape & Vogt 85 ANO series uprights, length in accordance with drawings.
   4. Shelf Brackets: 16 gauge (1.6 mm thick) bookend type, as detailed on drawings.
   5. Safety edging:
      a. Front Edge:
         1) Retainer rail.
      b. Rear edge:
         1) Retainer rail.
   6. Load capacity: System shall support a minimum of 35 pounds per square foot applied at all shelves simultaneously. Maximum deflection shall be 0.35 inches (9mm) under load.
7. Finish: Factory-finish steel tube support system, shelf standards, and brackets with epoxy powder coating. Color to be selected by the Architect.

D. Adjustable Wall Shelves:
1. Shelving: High-Pressure Decorative Laminate shelving as specified above.
2. Double Slot Shelf Standards:
   a. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.
      1). Knape & Vogt Manufacturing Company, 2700 Oak Industrial Drive NE, Grand Rapids, MI 49505 Tel: 616 459-3311.
      2). Approved substitution.
   b. Basis of Design: Knape & Vogt 85 ANO series uprights, or equal. Length as indicated on the drawings.
3. Shelf Brackets: 16 gauge (1.6 mm) bookend type, as detailed on drawings.
4. Safety edging:
   a. Front Edge:
      1). Retainer rail.
   a. Front and side edges (where indicated):
      1). Retainer rail.
5. Load capacity: System shall support a minimum of 35 pounds per square foot applied at all shelves simultaneously. Maximum deflection shall be 0.35 inches (9mm) under load.
6. Finish: Factory finish standards and brackets with epoxy powder coating. Color to be selected by the Architect.

E. Chemical Resistant Shelf Units:
1. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.
   a. InterMetro Industries Corporation, 651 North Washington St., Wilkes-Barre, PA 18705 Tel: 800 992-1776. Manufacturer of Metro product range.
   b. Eagle Group, 100 Industrial Blvd., Clayton, DE 19938 Tel: 302 653-3000.
   c. Approved substitution.
2. Description: Chemical-resistant polymer shelving, posts, components and accessories.
3. Basis of Design: MetroMax storage system, floor-mounted post supported, or equivalent.
   a. Posts: floor mounted polymer posts, adjustable at 1 inch (25 mm), minimum, increments, length as shown on drawings, Metro PE series or equal.
   b. Shelves: Open grid design with post connectors, Metro GX2 series or equal.
      1). Provide solid shelf mat, Metro FX2 series or equal.
   c. Provide diagonal bracing for lateral stability at freestanding applications.
   d. Accessories:
      1). Foot Plate: stainless steel with adjustable leveling bolt for polymer shelving, Metro No. 9993S or equal.
      2). Post Clamps: Zinc-plated, to join adjacent polymer posts, Metro No. 9994Z or equal.
3). Shelf Ledges: Stackable, 2 inch (51 mm) high polymer, Metro No. LxxxX-2S or equal, sized to match shelf.

2.7 MODULAR PARTS BINS

A. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.

1. Lyon Metal Products, P. O. Box 671, Aurora, IL 60507 Tel: 800 323-0096.
2. Penco Products, Inc., P. O. Box 378, 99 Brower Ave., Oaks, PA 19456 Tel: 800 562-1000.
3. Hallowell, Division of List Industries Inc., 5711 Distribution Dr., Memphis, TN 38141 Tel: 901 375-0022.
4. Approved substitution

B. Basis of Design: Lyon Metal Products 8000 Series with Modular Drawers, Shelves, and Accessories as noted.

C. Features:

1. Premium grade 18 gauge (1.0 mm thick) steel drawer and shelf unit comprised of modular drawers and adjustable shelves on 1 ½ inch (38 mm), maximum, increments, and 84 inches (2134 mm) high 14 gauge (2.0 mm thick) closed post supports with solid panels. Size in accordance with Laboratory Furnishings plans and details.
2. Drawers to operate on smooth rolling ball-bearing suspension, which supports loads up to 400 pounds per drawer.
3. Each drawer features full length roll-formed steel handles with 1-1/4” label holders.

D. Required Accessories and Options:

1. Provide pre-engineered modular drawer steel partitions and aluminum dividers as noted on drawings, sized for the drawer heights shown.
2. Back Panel with Back-to-Shelf Clips
3. Drawer Finishing Strips
4. Base Strips
5. Drawer Guide Supports
6. Shim Plates
7. Anchor Feet

E. Color: Selected by Architect from manufacturer’s full color line.

F. Provide all components required for a complete finished and functioning assembly including all bolts, clips, and all other parts necessary.

2.8 CYLINDER RACKS AND RESTRAINT ASSEMBLIES

A. Cylinder Rack Assembly:

1. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.

   a. Kumar Industries, 4775 Chino Avenue, Chino, CA 91710 Tel: 909 591-0722.
a. Matheson Tri-Gas, 166 Keystone Drive, Montgomeryville, PA 18936 Tel: 215 648-4000.
a. Scott Specialty Gases, Inc., 6141 Easton Road Box 310, Plumsteadville, PA 18949 Tel: 215 766-8861.
b. Approved substitution.

2. Frame members: 2 inches x 2 inches x 1/8 inch (50 x 50 x 3 mm) square steel tube.
3. Construction: Refer to the Laboratory Furnishings drawings for details. Construction to be fully welded. Weld cover plates to close exposed tube ends. Grind and polish all welds to produce smooth surface with no visible evidence of welding when painted. Sizing:
   a. Size typical units to accommodate standard-size laboratory gas cylinders.
   b. Where shown on drawings, size units to accommodate liquefied gas dewars.
4. Chain: Provide restrainers of 5/16 inch diameter, Type 304 stainless steel welded chain fitted with stainless steel snap shackle with swivel clevis and split ring for each bracket; McMaster-Carr Supply Company, Suncor Marine & Industrial, Inc., or approved substitution.
5. Cylinder rack steel components shall be factory-finished to match the casework metal color as selected for the project.

B. Cylinder Restraint Assembly:
1. Framing channel, Fittings, Swivel Hangers, and End Caps: Slotted channel framing as specified elsewhere on this Section.
2. Provide two swivel hangers per cylinder or dewar per wall bracket
3. Sizing:
   a. Size typical units to accommodate standard-size laboratory gas cylinders.
   b. Where shown on drawings, size units to accommodate liquefied gas dewars.
4. Chain: Provide restrainers of 5/16 inch diameter, Type 304 stainless steel welded chain fitted with stainless steel snap shackle with swivel clevis and split ring for each bracket; McMaster-Carr Supply Company, Suncor Marine & Industrial, Inc., or approved substitution.
5. Cylinder restraint steel components shall be factory-finished to match the casework metal color as selected for the project.

2.9 PIPE DROP ENCLOSURE
A. Fabricate pipe drop enclosures from minimum 18 gauge (1.3 mm thick) galvanized steel, per details shown on the Laboratory Furnishings drawings, except as noted.
1. Pipe drop enclosures at the following locations shall be fabricated of 18 gauge, Type 304 stainless steel with a No. 4 finish:
   a. At scullery sinks.
   b. At stainless steel counters.
B. Seal all joints between dissimilar metals and at all panel seams with clear silicone sealant.
C. Materials and finish shall be as specified under Metals Fabrications in this Section.
2.10 DRYING RACK

A. Stainless Steel Drying Rack with White Polypropylene Pegs:

1. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.
   a. Inter Dyne Systems, Inc., 676 Ellis Road, Norton Shores, MI 49441 Tel: 231 799-8760.
   b. Approved substitution (no known equal).

   a. Drying rack bodies shall be of one-piece design and of not less than 20 gauge (1.0 mm thick) Type 304 stainless steel with a No. 4 finish. The top shall have two 90-degree bends, and sides to have one 90 degree bend.
   b. Each rack shall have an integral full-width 20 gauge (1.0 mm thick), Type 304 stainless steel drip trough with stainless steel drain tube. Drip trough shall be continuously welded.
   c. The trough shall have a full-length, Type 304 stainless steel wire mesh screen insert. Screen insert shall be turned down on all four sides to provide a clean and finished appearance.
   d. Each rack front shall be dimensioned and punched with T-shaped holes to accommodate the peg arrangement shown on the drawings.

3. Pegs shall fit into the punched holes in the rack front. A T-shaped protrusion on the base of the pegs shall allow easy removal and replacement without the need for tools. The T-shaped holes shall be designed to fit the protrusion on support pegs for holding single or multiple utensil drip trays, drain shelves, funnel racks or pipette holders. Pegs shall be of injection-molded white polypropylene.

4. Provide wall hangers for each rack, designed to enable the removal and replacement of the entire rack for cleaning without the need for tools.

5. Provide stainless steel fixing screws of appropriate type for attachment to support structure.

6. Provide clear, tight-fitting hose to drain from drip trough drain tube into sink.

7. Provide finished stainless steel back panel when any portion of the back of drying rack is exposed.

2.11 CABLE / VACUUM LINE THROUGH PORT (STAINLESS STEEL BENCHTOP SLEEVE/GROMMET)

A. Provide 3 inch (75 mm) diameter wire or cable access through ports of Type 304 stainless steel with No. 4 finish at bench tops as located and detailed on the Laboratory Furnishings drawings.

2.12 PLASTIC GROMMET AND OTHER ACCESSORIES

A. Round Grommets:

1. Size: 2 3/8 inch (60 mm) O.D.
2. Material: Plastic
3. Accessories: Removable slotted plastic cover
4. Color: To be selected by Architect.
6. Refer to plans for location.
7. Manufacturers: Products complying with this specification may be provided by the following manufacturers.
   a. Doug Mockett & Company, Inc., Box 3333, Manhattan Beach, CA 90266 Tel: 800 523-1269.
   b. Häfele America Inc., 3901 Cheyenne Dr., P. O. Box 4000, Archdale, NC 27263 Tel: 336 889-2322.
   c. Approved equal.

B. Utility Management Hook
   1. Type 303 stainless steel hook with polished finish.
   2. Size: 4 23/32 inch tall, 2 43/64 inch wide.
   3. Load capacity: 22 pounds.
   5. Manufacturer: McMaster Carr, P.O. Box 54960, Los Angeles, CA 90054-0960 Tel: 562 692-5911, or approved equal.

C. Grilles
   1. Air intake grilles: Perforated metal mesh in a metal frame.
   2. Sizes: As shown on drawings.
   6. Manufacturer: Doug Mockett & Co., Inc. P.O. Box 3333, Manhattan Beach, CA 90266 Tel 800 523-1269 or approved equal.

D. Backpack Hooks

2.13 FINISH FOR MISCELLANEOUS WOOD ITEMS

A. Applicability: This section applies to wood fabrications, including, but not limited to, wood laboratory tables, wood-framed balance tables, wood-framed pegboards, and wood filler panels.

B. Finish:
   1. Manufacturer may uses either of the following finish systems:
      a. Customized, high-solids, cross-linked, ultraviolet light (UV)-cured coating developed for durability, including abrasion, chemical, impact, and scratch resistance, for flat-line applications. Coatings shall have little or no VOCs. Chemical-resistant modified acrylic urethane finish with built-in UV blocker, or equal, applied over permanent wood stain.
   2. Stain Color:
      a. Match No. 102 Seaside Oak as manufactured by Kewaunee Scientific Corporation, subject to Architect’s approval.
   3. Application:
      a. Finish application and sequence shall be as recommended and designed by the manufacturer for a high quality, laboratory-grade wood casework finish.
      b. Preparation: Sand exposed surfaces smooth, free from dirt and defects.
c. Stain application: Apply stain of color selected to all exposed casework surfaces. Apply in a manner to achieve a match with the selected color sample upon completion of application of the finish.

d. Finish application: Apply top finish to all stained surfaces. Finished surfaces shall be even, water-clear and bright. Cloudy or muddy finishes carrying tinting pigments will not be acceptable.

e. Stain Color:
   1) Match No. 102 Seaside Oak as manufactured by Kewaunee Scientific Corporation, subject to Architect’s approval.

C. Wood Finish Chemical Resistance Performance Requirements:

1. Manufacturer shall submit wood finish chemical resistance performance test results. Testing to be performed by independent testing agency.

2. Procedure: Place panel on a flat surface, clean with soap and water and blot dry. Condition the panel for 48 hours at 73 +/- 3 degrees Fahrenheit (23º +/- 2ºC) and 50 +/- 5% relative humidity or the currently accepted guideline set by ASTM. Test the panel for chemical resistance using forty-nine different chemical reagents by one of the following methods. For both methods, leave the reagents on the panel for a period of one hour. Wash off the panel with water, clean with detergent and naptha, and rinse with deionized water. Dry with a towel and evaluate after 24-hours at 73º +/- 3ºF (23º +/- 2ºC) and 50 +/- 5% relative humidity, or the currently accepted guideline set by ASTM.

   a. Method A: Test volatile chemicals by placing a cotton ball saturated with reagent in the mouth of a one-ounce (29.574cc) bottle and inverting the bottle on the surface of the panel.

   b. Method B: Test non-volatile chemicals by placing five drops of the reagent on the surface of the panel and covering with a 24mm watch glass, concave side down.

3. Rating System: Evaluations shall use the following rating system:

   - Level 0: No detectable change.
   - Level 1: Slight change in color or gloss.
   - Level 2: Slight surface etching or severe staining.
   - Level 3: Pitting, cratering, swelling, or erosion of coating. Obvious and significant deterioration.

4. Acceptance Level:

   a. Individual test results for the specified 49 reagents shall be within the Range for that reagent as specified on the table below.

   b. There shall be no more than four (4) Level 3 conditions.

5. Table of reagents:

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Chemical Reagent</th>
<th>Test Method</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acetate, Amyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>2.</td>
<td>Acetate, Ethyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>3.</td>
<td>Acetic Acid, 98%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>4.</td>
<td>Acetone</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>5.</td>
<td>Acid Dichromate, 5%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>6.</td>
<td>Alcohol, Butyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>7.</td>
<td>Alcohol, Ethyl</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>8.</td>
<td>Alcohol, Methyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>9.</td>
<td>Ammonium Hydroxide, 28%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>10.</td>
<td>Benzene</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>11.</td>
<td>Carbon Tetrachloride</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>12.</td>
<td>Chloroform</td>
<td>A</td>
<td>0</td>
</tr>
</tbody>
</table>
### Test No. Chemical Reagent Test Method Range

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Chemical Reagent</th>
<th>Test Method</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.</td>
<td>Chromic Acid, 60%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>14.</td>
<td>Cresol</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>15.</td>
<td>Dichloroacetic Acid</td>
<td>A</td>
<td>0-3</td>
</tr>
<tr>
<td>16.</td>
<td>Dimethylformamide</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>17.</td>
<td>Dioxane</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>18.</td>
<td>Ethyl Ether</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>19.</td>
<td>Formaldehyde, 37%</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>20.</td>
<td>Formic Acid, 90%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>21.</td>
<td>Furfural</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>22.</td>
<td>Gasoline</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>23.</td>
<td>Hydrofluoric Acid, 37%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>24.</td>
<td>Hydrofluoric Acid, 48%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>25.</td>
<td>Hydrogen Peroxide, 30%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>26.</td>
<td>Iodine, Tincture of</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>27.</td>
<td>Methyl Ethyl Ketone</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>28.</td>
<td>Methylene Chloride</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>29.</td>
<td>Monochlorobenzene</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>30.</td>
<td>Naphthalene</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>31.</td>
<td>Nitric Acid, 20%</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>32.</td>
<td>Nitric Acid, 30%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>33.</td>
<td>Nitric Acid, 70%</td>
<td>B</td>
<td>2-3</td>
</tr>
<tr>
<td>34.</td>
<td>Phenol, 90%</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>35.</td>
<td>Phosphoric Acid, 85%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>36.</td>
<td>Silver Nitrate Saturated</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>37.</td>
<td>Sodium Hydroxide 10%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>38.</td>
<td>Sodium Hydroxide 20%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>39.</td>
<td>Sodium Hydroxide 40%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>40.</td>
<td>Sodium Hydroxide Flake</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>41.</td>
<td>Sodium Sulfide Saturated</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>42.</td>
<td>Sulfuric Acid, 33%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>43.</td>
<td>Sulfuric Acid, 77%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>44.</td>
<td>Sulfuric Acid, 96%</td>
<td>B</td>
<td>1-3</td>
</tr>
<tr>
<td>45.</td>
<td>Sulfuric Acid 77% &amp; Nitric Acid 70%</td>
<td>B</td>
<td>1-3</td>
</tr>
<tr>
<td>46.</td>
<td>Toluene</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>47.</td>
<td>Trichloroethylene</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>48.</td>
<td>Xylene</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>49.</td>
<td>Zinc Chloride, Saturated</td>
<td>B</td>
<td>0</td>
</tr>
</tbody>
</table>

#### 2.14 METAL FABRICATIONS

**A. Applicability:** This section applies to metal fabrications, including, but not limited to, pipe drop enclosures, radioisotope storage cabinets, shelving support systems, metal-framed laboratory tables, metal-framed balance tables, cylinder racks, utility ceiling tiles, and other miscellaneous brake-formed and shop fabricated components and trim, such as required for overhead service carriers.

**B. Manufacturers:** Products complying with this specification may be provided by the following manufacturers, and/or other manufacturers that may be listed under individual products within this specification.

1. Kumar Industries, 4775 Chino Avenue, Chino, CA 91710 Tel: 909 591-0722.
2. Approved substitution.

C. Materials:

1. Steel: Cold-rolled furniture stock sheet steel, prime grade, roller leveled.
   a. Steel shall be treated at the mill to be free of scale, ragged edges, deep scratches, or other injurious effects.
   b. All gauges indicated are to be U.S. standard.

D. Finish Requirements:

1. Paint finish for steel laboratory products shall utilize a dry coating process with minimal waste generation. Liquid-applied coatings shall not be acceptable. Manufacturer shall supply documentation that waste generated during the painting process, is a solid, non-hazardous material.
   a. Pretreatment: Finish process shall incorporate a phosphate conversion coating during the pretreatment/cleaning operation.
   b. Operator Protection: The painting process shall be cleanly contained, have no solvent odor and be performed in an air-conditioned room.
   c. VOC (Volatile Organic Compounds) emissions shall not exceed 0.29 pounds per gallon (35 g/L).
   d. Offgasing: No further emissions or “Offgasing/Decomposition” vapors shall occur at room temperature from installed finished parts.

2. Preparation: After the units have been completely welded together and before finishing, they shall be given a pre-paint treatment to provide excellent adhesion of the finish to the metal and to aid in the prevention of corrosion. Physical and chemical cleaning of the metal shall be accomplished by washing with an alkaline cleaner, followed by a spray treatment with a heated cleaner/phosphate solution and pretreated with iron phosphate spray followed by a neutral final seal prior to application of final finish. The strength of each solution shall be monitored by filtration to insure consistent quality. All treated parts shall be immediately dried in heated ovens and gradually cooled before application of the finish. Treated metal parts shall be clean and properly prepared to provide optimum adhesion of finish and resistance to corrosion.

3. Application: Electrostatically apply powder coat of selected color and bake in controlled high temperature oven to assure a smooth, hard satin finish. Surfaces shall have a chemical resistant, high grade laboratory furniture quality finish of the following thicknesses:
   a. All surfaces, exterior or interior, exposed to view, shall receive sufficient powder coat to achieve an average 1.5 mil (38 µm) film thickness with a minimum 1.2 mil (30 µm) film thickness and shall have smooth satin luster.
   b. Backs of cabinets and other surfaces not exposed to view shall have sufficient powder coat to achieve an average 1.0 mil (25 µm) film thickness.

4. All drawer bodies to be finished in matching color.

5. Concealed interior parts shall receive corrosion-resistant treatment.

6. Finish must be UV stable.

7. Color: As selected by the Architect.

E. Finish Performance Requirements:

1. Manufacturer shall submit metal finish performance testing results. Testing to be performed by independent testing agency.

2. Chemical Resistance:
a. Test procedure: Place samples on a flat surface, clean with soap and water and blot dry. Condition the panel for 48 hours at 73 +/- 3 degrees Fahrenheit (23(+ 2°C) and 50+ 5% relative humidity, or the currently accepted guideline set by ASTM. Test the samples for chemical resistance using forty-nine different chemical reagents by one of the following methods. For both methods, leave the reagents on the sample for a period of one hour. Wash off the sample with water, clean with detergent and naptha, and rinse with deionized water. Dry with a towel and evaluate after 24 hours at 73 +/- 3 degrees Fahrenheit (23°± 2°C) and 50± 5% relative humidity, or the currently accepted guideline set by ASTM

1). Method A: Test volatile chemicals by placing a cotton ball saturated with reagent in the mouth of a 1 ounce (29.574cc) bottle and inverting the bottle on the surface of the sample. The cotton ball shall remain in contact with the sample for the duration of the test.

2). Method B: Test non-volatile chemicals by placing five drops of the reagent on the surface of the sample and covering with a 24mm watch glass, convex side down.

b. Rating System: Evaluations shall use the following rating system:

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No detectable change.</td>
</tr>
<tr>
<td>1</td>
<td>Slight change in color or gloss.</td>
</tr>
<tr>
<td>2</td>
<td>Slight surface etching or severe staining.</td>
</tr>
<tr>
<td>3</td>
<td>Pitting, cratering, swelling, or erosion of coating. Obvious and significant deterioration.</td>
</tr>
</tbody>
</table>

c. Acceptance Level:

1). Individual test results for the specified 49 reagents shall be within the Range for that reagent as specified on the table below.

2). There shall be no more than four (4) Level 3 conditions.

d. Table of reagents:

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Chemical Reagent</th>
<th>Test Method</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acetate, Amyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>2.</td>
<td>Acetate, Ethyl</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>3.</td>
<td>Acetic Acid, 98%</td>
<td>B</td>
<td>0-3</td>
</tr>
<tr>
<td>4.</td>
<td>Acetone</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>5.</td>
<td>Acid Dichromate, 5%</td>
<td>B</td>
<td>0-1</td>
</tr>
<tr>
<td>6.</td>
<td>Alcohol, Butyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>7.</td>
<td>Alcohol, Ethyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>8.</td>
<td>Alcohol, Methyl</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>9.</td>
<td>Ammonium Hydroxide, 28%</td>
<td>B</td>
<td>0</td>
</tr>
<tr>
<td>10.</td>
<td>Benzene</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>11.</td>
<td>Carbon Tetrachloride</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>12.</td>
<td>Chloroform</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>13.</td>
<td>Chromic Acid, 60%</td>
<td>B</td>
<td>0-2</td>
</tr>
<tr>
<td>14.</td>
<td>Cresol</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>15.</td>
<td>Dichloroacetic Acid</td>
<td>A</td>
<td>0-3</td>
</tr>
<tr>
<td>16.</td>
<td>Dimethylformamide</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>17.</td>
<td>Dioxane</td>
<td>A</td>
<td>0-2</td>
</tr>
<tr>
<td>18.</td>
<td>Ethyl Ether</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>19.</td>
<td>Formaldehyde, 37%</td>
<td>A</td>
<td>0-1</td>
</tr>
<tr>
<td>20.</td>
<td>Formic Acid, 90%</td>
<td>B</td>
<td>0-3</td>
</tr>
<tr>
<td>21.</td>
<td>Furfural</td>
<td>A</td>
<td>0-3</td>
</tr>
<tr>
<td>22.</td>
<td>Gasoline</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>23.</td>
<td>Hydrofluoric Acid, 37%</td>
<td>B</td>
<td>0-2</td>
</tr>
</tbody>
</table>
### Test No. | Chemical Reagent | Test Method | Range
--- | --- | --- | ---
24. | Hydrofluoric Acid, 48% | B | 0-3
25. | Hydrogen Peroxide, 30% | B | 0-1
26. | Iodine, Tincture of | B | 0-2
27. | Methyl Ethyl Ketone | A | 0-2
28. | Methylene Chloride | A | 0-2
29. | Monochlorobenzene | A | 0-2
30. | Naphthalene | A | 0-1
31. | Nitric Acid, 20% | B | 0-1
32. | Nitric Acid, 30% | B | 0-1
33. | Nitric Acid, 70% | B | 0-3
34. | Phenol, 90% | A | 0-2
35. | Phosphoric Acid, 85% | B | 0-1
36. | Silver Nitrate Saturated | B | 0
37. | Sodium Hydroxide 10% | B | 0
38. | Sodium Hydroxide 20% | B | 0
39. | Sodium Hydroxide 40% | B | 0-1
40. | Sodium Hydroxide Flake | B | 0
41. | Sodium Sulfide Saturated | B | 0
42. | Sulfuric Acid, 33% | B | 0
43. | Sulfuric Acid, 77% | B | 0
44. | Sulfuric Acid, 96% | B | 2-3
45. | Sulfuric Acid 77% & Nitric Acid 70% equal parts | B | 1-3
46. | Toluene | A | 0-1
47. | Trichloroethylene | A | 0-1
48. | Xylene | A | 0-1
49. | Zinc Chloride, Saturated | B | 0

### Section 3: Hot Water Test
a. Test Procedure: 190 to 205 degrees Fahrenheit (88°C to 96°C) hot water shall be allowed to trickle (with a steady stream and at a rate of not less than 6 ounces (177.5 cc) per minute) on the finished surface, which shall be set at an angle of 45 degrees Fahrenheit for a period of 5 minutes.

b. Acceptance Level: After cooling and wiping dry, the finish shall show no visible effect from the hot water.

### Section 4: Paint Adhesion on Steel Test
a. Test Procedure: Test shall be based on ASTM D2197-86 “Standard Method of Test for Adhesion of Organic Coating.” Two sets of eleven parallel lines 1/16 inch (1.587 mm) apart shall be cut with a razor blade to intersect at right angles thus forming a grid to 100 squares. The cuts shall be made just deep enough to go through the coating, but not into the substrate. Brush surface lightly with a soft brush for one minute. Examine under 100 fc (1076 lux) of illumination.

b. Acceptance Level: Ninety or more of the squares shall show finish intact.

### Section 5: Impact Test
a. Test Procedure: Drop a 1 pound (0.4536 kg) ball approximately 2 inches (50.8 mm) in diameter from a distance of 12 inches (305 mm), onto a flat horizontal surface, coated to manufacturer’s standard manufacturing method.

b. Acceptance Level: No visual evidence to the naked eye of cracks in the finish due to impact.

### Section 6: Paint Hardness on Steel Test
a. Test Procedure: Paint film shall be tested with pencils of various hardnesses. Pencils shall have a wide, sharp edge. Pencils shall be pushed across surface in a chisel-like manner.

b. Acceptance Level: Finish film shall not rupture from a sharpened 4H pencil.

2.15 STAINLESS STEEL FABRICATIONS

A. Applicability: This section applies to stainless steel fabrications, including, but not limited to, work surfaces, canopy hoods, drying racks, sinks, stainless steel pipe drop enclosures, and other miscellaneous brake-formed and shop fabricated stainless steel components and trim as shown on the drawings.

B. Manufacturers:

1. The Diamond Group, 895 Munch Street, Laval, Quebec H7S 1A9 Canada Tel: 450 668-0330.
2. Inter Dyne Systems, Inc., 676 Ellis Road, Norton Shores, MI 49441 Tel: 231 799-8760.
4. Approved substitution.

C. Materials and Finishes:

1. Unless otherwise noted stainless steel shall be Type 304 and shall be of gauge indicated on Laboratory Furnishing drawings or this specification.
2. All fabrications shall have exposed surfaces ground and polished to a No. 4 satin finish.
3. All stainless steel nuts, screws, bolts, and rivets, etc., shall be of the same type stainless as in the sheet material and shall have a tumbled finish closely resembling that of a No. 4 finish.
4. All stainless steel welding material shall be of type similar to the sheet material or a richer quality. All welds shall be made without discoloration and shall be ground, polished, and passivated to blend harmoniously with a No. 4 satin finish. All joints in stainless steel tops and work surfaces shall be welded.

D. Work Surfaces:

1. Thickness: 16 gauge (1.6 mm).
2. Fabrication:
   a. Edges: Flanged down the same dimension as the adjacent non-stainless top, with 1 inch (25 mm) being a minimum and returned over a perimeter metal frame to simplify securing top material to cabinet or structural frame.
   b. Reinforcement: Under-surface shall be reinforced with full length 16 gauge (1.6 mm) structural metal channels as required to insure rigidity and prevent buckling, warping, or oil canning. Where bench-mounted fittings are indicated on the drawings, provide top reinforcement to allow for rigid, secure mounting of fittings.
   c. Undercoating: Underside of top shall have a heavy mastic agent coating providing sound deadening.
   d. Stainless steel sides and backsplashes, where indicated, shall be integrally welded to top and finish as indicated above. The back side of exposed backsplashes shall be finished to match front and sides.
   e. Provide all holes and cutouts as required for built-in equipment and mechanical and electrical service fixtures. Verify size of opening with actual size of equipment to be used prior to making openings. Form inside corners to a radius of not less than 1/8 inch (3 mm). After sawing, rout and file cutouts to ensure smooth, crack-free edges with no burrs.
3. Tops with Sinks: Tops and sinks shall be integral, fabricated with a marine edge and shall be pitched to sink bowl for proper drainage. Marine edges shall be seamless die-formed.
4. Flat Stainless Steel Work Surfaces: (Without marine edge or sink) Shall have an integrally coved backsplash and bull-nose at front edge of work surface.
5. Wall-Supported Benchtop
   a. Benchtops shall be fabricated as per construction section of this specification with stainless steel wall support and bracket angles all as per Laboratory Furnishings Drawings.
   b. Unit shall be designed to support 200 pounds per square foot, completely wall supported with no legs or support members extending to the floor.
6. Joints: Fabricate work surfaces in the largest sections practical for delivery to the job site. All joints shall be field-welded, ground smooth, and polished on-site to create a continuous work surface.

E. Laboratory Sink: Integral one piece construction with stainless steel work surface.
   1. Thickness: 18 gauge (1.3 mm thick), unless otherwise noted.
   2. Construction: Sink units shall be designed and fabricated with sufficient reinforcement to prevent oil canning. All sink joints shall be butt-welded, ground smooth by the heliarc welding process. Inside radii shall be 1 inch (25 mm). Bottoms shall be pitched to the drain indent. No soldering will be permitted in connection with sink construction. Sink bowl dimensions given are inside dimensions. Underside shall have a heavy mastic agent coating providing sound deadening.

F. Canopy Hood: Provide stainless steel canopy with all hangers and miscellaneous hardware at locations and sizes as indicated on the Laboratory Furnishings drawings.
   1. Thickness: 18 gauge.
   2. Construction: Provide reinforcing necessary to prevent oil canning or deflection of panel between supports. All corners and joints shall be welded, ground smooth and free of all defects. Welded joints with visible burn marks will not be accepted.
   3. Accessories: Provide stainless steel hangers and miscellaneous support hardware as required for a complete installation.
   4. Provide exhaust duct transition piece for mechanical connection above the ceiling under Division 23. Refer to the Exhaust Schedule on the drawings for required exhaust flow rate and connection diameter.

2.16 SLOTTED CHANNEL FRAMING

A. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.
   1. Unistrut, 35660 Clinton Street, Wayne, MI 48184 Tel: 800 521-7730.
   3. Kumar Industries (Nu-Strut), 4881 Chino Ave., Chino, CA 91710 Tel: 909 591-0722.
   4. Cooper B-Line Inc. (B-Line), 509 West Monroe St., Highland, IL 62249 Tel: 618 654-2184.
   5. Approved substitution.

B. Materials: Channel and framing members shall be fabricated from steel conforming to the following requirements:
   1. Framing Members:

b. Exposed Framing Members and Fittings: ASTM A446 GR A with zinc coating conforming to ASTM A525.

c. Stainless Steel Framing Members and Fittings: ASTM A240 (Type 304), where indicated.

2. Fittings:

a. Concealed Fittings: Fabricate from steel satisfying the requirements of ASTM A570 GR 33, and conform to the following ASTM specifications: A575, A576, A36, or A635. Nuts shall conform to ASTM A576 GR 1015 and screws shall conform to SAE J429 GR 2 and ASTM A307.

b. Exposed Fittings: Fabricate from steel satisfying the requirements of ASTM A570 GR 33, and conform to the following ASTM specifications: A575, A576, A36, or A635. Nuts shall conform to ASTM A576 GR 1015 and screws shall conform to SAE J429 GR 2 and ASTM A307. Exposed fittings shall receive zinc coating conforming to ASTM A525.

c. Stainless Steel Fittings and Hardware: Sintered Nuts shall be of ASTM B783 (Type 316N2-33) stainless steel and fittings shall be of ASTM A240 (Type 304) stainless steel. Stainless steel fittings and hardware shall be used with stainless steel framing members, or where indicated.

3. Thickness: 12 gauge, unless noted otherwise.

4. Size: 1 5/8 inch x 1 5/8 inch cross-section, unless noted otherwise.

C. Components:

1. The following components shall be provided, unless otherwise noted:


b. Suspended Framing Channel, 3 ¼ inch x 1 5/8 inch x 12 gauge: Unistrut P5000, Powerstrut PS 100, Kumar Industries N-150, B-Line Systems, Inc. B11, or equal.

c. 90° Angle Fitting: 4 1/8 inch x 3½ inch x ¼ inch with two holes, each leg: Unistrut P1325, Powerstrut PS 607, Kumar Industries N-1123, B-Line Systems, Inc. B104, or equal.

d. 135° Angle Fitting: 3 inch x 2 5/16 inch x ¼ inch with one hole, each leg: Unistrut P1546, Powerstrut PS 633-45°, Kumar Industries N-1425, B-Line Systems, Inc. B154, or equal.

e. T-Shaped Flat Plate Fitting: 5 3/8 inch x 3½ inch x ¼ inch plate, T-shaped, with four holes: Unistrut P1031, Powerstrut PS 714, Kumar Industries N-1022, B-Line Systems, Inc. B133, or equal.

f. Wing Shape Fitting, 9 5/32 inch x 3 7/8 inch ten holes, two holes in each wing section and two holes in each of three channel section sides: Unistrut P2347, Powerstrut PS 913, B-Line Systems, Inc. B273.


i. Slotted Hole Framing Channel, 1 5/8 inch x 1 5/8 inch x 12 gauge framing channel with 13/32 inch x 3 inch slotted holes, 4 inches on center: Unistrut P1000 SL, Powerstrut P 200 S, Kumar Industries N-200-SL, B-Line Systems, Inc. B22S.
j. Slotted Framing Channel for installation in Chemical Fume Hoods, 1 5/8 inch x 13/16 inch x 16 gauge Type 316 stainless steel framing channel: Unistrut P4000 SS, Powerstrut PS 560 SS, Kumar Industries, B-Line Systems, Inc.

1). Attach channel to side of fume hood with 2 5/8 inch x 1 7/8 inch x 1/8 inch, 4 hole, stainless steel 90º fitting: Unistrut P6325 SS, Powerstrut, Kumar Industries, B-Line Systems, Inc.


m. End Caps: 0.06 inches thick for framing channel: Unistrut P1280, Powerstrut PS 707, Kumar Industries N-2500, B-Line Systems, Inc. B205, or equal. Provide end caps for all exposed horizontal framing channels.

n. Ceiling Escutcheon: Provide 18 gauge steel, finished to match framing members, as indicated on the Laboratory Furnishing drawings, at ceiling penetrations.

o. Other components, hardware, and fasteners, as required for a complete assembly and as indicated on the drawings.

2. Service Struts and Ledging:

a. 16 gauge, 13/16 inch x 1 5/8 inch cold-formed framing uprights: Unistrut P4000, Powerstrut PS 560, Kumar Industries N-400, B-Line Systems, Inc. B56, or equal. Uprights shall be provided at 48 inches, maximum, and fastened top and bottom by two adjustable U-shaped spreaders.

b. U-shaped spreaders: 12 gauge by 1 ½ inch (45 mm) wide by length required, galvanized steel.

c. Locations:

1). Provide to support tops at pipe service chase space, support drain troughs, under fume hood superstructures, and other abnormal loads.

2). Support struts with U-shaped spreaders shall be provided at 48 inches (1220 mm) on center below island and peninsula benches, as indicated on drawings. Support struts shall be provided along wall 48 inches (1220 mm) on center below island and peninsula benches. Struts will be used to support piped and electrical services installed under Divisions 22, 26, and 27. Provide all bolts, expansion sleeves, and fastening devices for a complete assembly. Pipe and conduit hangers shall be provided by Division 22, 26, and 27 installers.

3. Cylinder and Dewar Restraint:

a. Swivel Hanger: 1 ¾ inch long by 3/8 inch diameter link welded to threaded stud; provide two per cylinder: Unistrut M2350, Powerstrut PS205, Kumar N-2911, B-Line 446B.

4. Finish:

a. Provide finish coating for all cold-formed framing components, except for stainless steel components.

b. Concealed Framing Members and Fittings: Rust inhibiting acrylic enamel paint applied by electrostatic deposition, after cleaning and phosphating, and thoroughly baked. Finish shall withstand a minimum of 400 hours salt spray when tested in accordance with ASTM B117. Color: Green.

c. Exposed Framing Members and Fittings: Factory applied epoxy powder coat. Color: To be selected by the Architect.
2.17 SEALANT

A. Manufacturers: Products complying with this specification may be provided by the following manufacturers.
   1. Dow Corning Corporation, P.O. Box 994, Midland, MI 48686 Tel: 989 496-7881.
   3. C.R. Laurence Company, Inc., 600 Wharton Drive, Atlanta, GA 30336 Tel: 404 696-3445
   4. Approved substitution.

B. Basis of Design: Dow Corning 732 Multi-Purpose Sealant, GE Silicones RTV 100 Series, C.R. Laurence CRL 33S Silicone, or equal.

C. Characteristics:
   1. Type: One-part silicone rubber, MIL-A-46106.
   3. Cure: Cures at room temperature on exposure to water vapor in the air.
   4. Authorizations:
      a. FDA Regulation No. 21 CFR 177.2600.
      b. USDA Rating P1.
      c. NSF Rating C2.
      d. UL 150 C Rating, File No. E40195 (N).
   5. Properties:
      a. Tack Free Time, ASTM C-679: 45 minutes, maximum.
      c. Tensile Strength, ASTM D-412: 220 pounds per square inch, minimum.
      e. UV Resistance, ASTM C-793: Excellent.

PART 3 - EXECUTION

3.1 SITE CONDITIONS

A. Inspection:
   1. Prior to installation of the work of this Section, carefully inspect the installed work specified in other Sections and verify that all such work is complete to the point where this installation may properly commence.
   2. Verify that all work may be installed in complete accordance with the original design, reviewed submittals, and the manufacturer’s recommendations.
   3. Where floor conditions require shimming or leveling of more than ¾ inch at any point, do not install casework in those locations. Notify the contractor and design team that remedial measures will be required to bring the floors closer to a level situation.

B. Discrepancy: In the event of discrepancy, immediately notify the Architect.

3.2 INSTALLATION

A. Coordinate work with any Owner furnished and/or installed components indicated on drawings.
B. General: Assemble units into one integral unit with joints flush, tight, and uniform. Align similar adjoining units to a tolerance of 1/16 inch (1.5 mm).

C. Cabinets:
1. Install cabinets to create a plumb, level, true and straight installation.
2. Installation of metal casework fixed cabinets shall utilize the internal leveling devices. Do not use shims.
3. Installation of wood casework shall be performed using shims. Shimming shall be minimized as much as possible, yet be sufficient to achieve a level and plumb condition.
4. Installation shall maintain the required height of countertops, but in all cases must stay within the range required by the ADA regulations.
5. Securely fasten wall units to solid supporting material, not plaster, lath, or wallboard. Anchor, adjust, and align wall cabinets as specified for base cabinets. Verify that all required backing and reinforcement necessary to support wall-mounted units is in place, secure, and accurately located.

D. Installation materials:
1. Installation of wood may involve the use of shims, spacers, cleats, straps and other such items of either metal or wood composition.
2. Installation of metal casework shall use spacers, cleats, and straps of galvanized steel, epoxy-coated steel, or stainless steel. No wood materials of any sort shall be part of the permanent installation of metal casework.
3. Installation of stainless steel counters shall use spacers, cleats, and straps of stainless steel of the stainless steel type specified for the casework construction. No wood or carbon steel materials of any sort shall be part of the permanent installation of stainless steel casework.

E. Laboratory Tops:
1. Scribe tops as necessary for close and accurate fit. Joints between worksurfaces, backsplashes, and adjacent items, penetrations, or similar shall be hairline joints, with a maximum width of 1/16 inch.
2. Field Joints: Factory-prepared and identical to factory joints, locate only where indicated on approved Shop Drawings. Field processing of top and edge surfaces is not acceptable, except as described by manufacturer in approved Submittal Data. Provide full length, one-piece tops and backsplashes wherever possible, and keep field joints to an absolute minimum.
3. Abut top and edge surface in one true plane, with internal supports placed to prevent any deflection. Joints in top units shall be flush and the narrowest for the respective materials of construction. Cement top joints and laboratory sinks in accordance with the manufacturers’ specifications.
4. All joints in stainless steel work surfaces shall be field-welded, ground smooth, and polished on site to create a continuous work surface.

F. Sealant:
1. Caulk edges of tops, backsplashes and side splashes to adjacent wall surface with silicone sealant.

3.3 DESTRUCTIVE TESTING

A. The Owner, Architect, and/or Contractor may, at their own cost, elect to perform destructive testing on casework cabinet components (such as fronts, sides, etc.) to confirm compliance with the requirements of this specification. The casework manufacturer/installer should account for
the de-installation, repair, and reinstallation, or replacement of one cabinet that may be selected for destructive testing.

3.4 CLEANING AND PROTECTION

A. Repair or remove and replace defective work as approved by the Architect at no additional cost to the Owner.

B. Clean finished units, touch up as required, and remove and refinish damaged or soiled areas.

C. Cover tops with kraft paper or polyethylene sheeting and all other means necessary after installation for protection against scratching, soiling, and deterioration during remainder of construction period. Remove protection prior to final cleaning.

D. Clean counter tops with diluted dishwashing liquid and water leaving tops free of all grease and streaks. Use no wax or oils.

END OF SECTION
SECTION 115313 - FUME HOODS AND OTHER AIR CONTAINMENT UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES
   A. Chemical Fume Hoods, including bench mounted hoods
   B. Fume Extractor Arms (Snorkels)
   C. Fume Extractor Arms (Snorkels): High Temperature
   D. Canopy Hoods

1.2 RELATED SECTIONS
   A. Section 115310: Laboratory Casework and Other Furnishings
   B. Section 115343: Laboratory Service Fittings and Fixtures
   C. Division 22: Plumbing
   D. Division 23: Heating, Ventilating, and Air Conditioning (HVAC)
   E. Division 26: Electrical

1.3 REFERENCES
   A. Chemical fume hoods:
      2. Conform to the recommended practices for laboratory fume hoods published by the
         Scientific Equipment and Furniture Association: SEFA 1 Recommended Practices for
         Fume Hoods.

1.4 DESCRIPTION
   A. Provide equipment complete with accessories as described herein and shown on Laboratory
      Furnishings drawings.
   B. Chemical fume hoods:
      1. Fume hoods with accessories shall be pre-piped and pre-wired. Pre-pipe service fittings
         to single point connection at 6 inches (150 mm) above top of hood or as otherwise
         shown.
         a. Refer to Section 115343 and details on Laboratory Furnishings drawings for
            service fittings.
         b. P-trap, waste piping and tailpiece extensions for cupsinks shall be furnished and
            installed by Division 22. Comply with Division 22 requirements for piping and
            installation requirements for respective pre-piped services.
c. Pre-wire all electrical devices to junction box at top of hood. Comply with Division 26 requirements for electrical work.

1.5 SUBMITTALS

A. Refer to the General Conditions and Division 1 “Submittal Procedures” for submittal requirements. In addition to these requirements, provide submittal requirements specified herein.

B. Submittal requirements:
   1. Submittal shall be prepared individually for this specification section. Arrange product data, drawings and information for submission in a complete set for this specification section.
   2. Submittal shall contain complete data for all items of this specification section. Periodic or partial submittals of individual components within this specification section will be returned as incomplete and rejected.
   3. Submittals shall be organized by specification sequence with section and paragraph number identified.
   4. Equipment and components being proposed shall be clearly labeled with all options and accessories indicated and shall be for this specific project. All non-applicable options, items and components shall be deleted or struck.

C. Materials List/Product Data: Submit complete materials list, including catalog data of all materials, equipment, and products for Work specified in this Section. Include chemical resistance finish performance test results for any products specified in this section.

D. Shop Drawings: Submit complete shop fabrication and installation drawings, including plans, elevations, sections, details and schedules. Show relationship to adjoining materials and construction. Shop Drawings shall be in the form of reproducibles or photocopies, not to exceed 11 inches by 17 inches (A3) in size. Blueline prints are not acceptable.

E. Approved Substitution/Approved Equal: In addition to the items required in Division 1, all substitution requests shall include item-by-item comparison of the proposed substitution to this project specification. A copy of the project specification shall be submitted, with each item and subsection of the project specification marked as “Comply” or “Not Comply.” In any cases where “Not Comply” is indicated, an explanation of the relative advantages of the proposed design shall be provided.
   1. Substitution shall not affect dimensions shown on Drawings.
   2. The Contractor shall pay for changes to the building design, including engineering design, detailing, utility and service requirements, and construction costs caused by the requested substitution.
   3. Substitutions shall have no adverse effect on other trades, the construction schedule, or specified warranty requirements.
   4. Maintenance and service parts shall be locally available for the proposed substitution.

F. Samples: Submit two (2) samples of each type of specified finish and color range available.

G. Test Reports: Submit the following performance test reports.
   1. “As Manufactured” (AM) Fume Hood Testing in Manufacturing Facility: Provide certification that each type and size of fume hood has passed Flow Visualization and Face Velocity tests, and achieved an AM performance rating equal or better than 0.05
ppm with 4.0 Lpm tracer gas release rate when tested in accordance with ASHRAE 110-2016.

2. **Fume Hood Sound Level Certification:** Provide certification of fume hood compliance with design criteria for maximum allowable noise within laboratories.
   
a. At project design operating conditions for sash height and face velocity, test data of octave band analysis verifying hood is capable of a 50 NC or lower value when connected to a 50 NC (minimum) HVAC source. Measurements shall be taken 36 inches (915 mm) in front of open sash.

3. **Fume Hood Certification:** Submit “As Installed” (AI) test report as described elsewhere in this section.

**H. Operations/Maintenance Manuals:** At project close-out, submit for Architect's review and Owner's use, complete operating and maintenance manuals that describe proper operating procedures, maintenance and replacement schedules, component parts list, and closest factory representative for components and service.

### 1.6 QUALIFICATIONS

**A.** Work in this Section shall be performed by a firm having a minimum eight years documented experience, and an established organization and production facilities including all tools, equipment and special machinery necessary for specializing in the fabrication and installation of the type of equipment required with skilled personnel, factory trained workmen and an experienced engineering department. Each shall have the demonstrated knowledge, ability and the proven capability to produce the specified equipment of the required quality and the proven capacity to complete an installation of this size and type within the required time limits.

### 1.7 COORDINATION

**A.** Work of this Section requires close coordination with Work of Divisions 22, 23 and 26 as well as Work specified in other Sections. Sequence all Work to ensure an orderly progress in the project without removal of previously installed Work and so as to prevent damage to finishes and products.

**B.** Coordinate, furnish, and install chemical fume hoods designed for variable air volume (VAV) or constant air volume (CAV) operation as indicated in the mechanical drawings. The designed exhaust airflow control method (VAV or CAV) shall be confirmed and coordinated prior to submission and shall be clearly indicated in the submittal product documentation.

### 1.8 WARRANTY

**A.** Refer to the General Conditions and Division 1 “Product Requirements” for warranty requirements. In addition to these requirements, all products shall be warranted to be free from defects in materials and workmanship for a minimum period of one year following substantial completion. The manufacturer/ dealer/ subcontractor shall repair or replace any products (or parts thereof) that are found to be defective. Replacement will include any parts, labor, shipping, and travel expenses involved. Warranty replacement work must be scheduled in coordination with the Owner’s academic/research schedule, and may therefore require evening and/or weekend work.
PART 2 - PRODUCTS

2.1 ACCESSIBILITY FOR PERSONS WITH DISABILITIES

A. Where indicated on Laboratory Furnishings drawings, fume hoods shall be furnished and installed in a manner to make them accessible to persons with disabilities in accordance with the Americans with Disabilities Act and any state or local building code or regulation having jurisdiction. The height of the highest point of access to the work surface above finished floor shall not exceed 34 inches. Fittings for piped services and electrical receptacles and controls shall be of a design and in a location in order to be considered accessible.

2.2 CHEMICAL FUME HOODS

A. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be provided by a single manufacturer.

1. Air Master Systems Corporation, 6480 Norton Center Drive, Muskegon, MI 49441 Tel: 231 798-1111.
2. Bedcolab Ltd, 2305 Francis Hughes Avenue, Laval, Quebec, Canada H7S 1H5 Tel 514 384-2820.
3. CiF Lab Solutions L.P., 53 Courtland Avenue, Vaughan, ON Canada L4K 3T2 Tel: 905 738-5821.
4. ICI scientific, 1865 Highway 641 North, Paris, TN 38242-8814 Tel: 731-642-4251.
5. Kewaunee Scientific Corporation, P O Box 1842, Statesville, NC 28687 Tel: 704 873-7202.
6. Labconco Corporation, 8811 Prospect Avenue, Kansas City, MO 64132 Tel: 800 821-5525.
7. Mott Manufacturing Limited, 452 Hardy Road, P. O. Box 1120, Brantford, ON, Canada N3T 5T3 Tel: 519 752-7825.
8. Approved substitution.

B. Underwriters Laboratory Listing: Fume hoods shall be UL subject 1805 classified. Label shall be attached to the face of each fume hood indicating classification to the UL 1805 standard for Laboratory Fume Hoods.

C. Materials: The following materials shall be provided, unless superseded by the requirements listed below for specific fume hood types.

1. Steel:
   a. ASTM A366 mild steel, furniture stock, cold-rolled, pickled, double annealed, and free from rust, scale, scratches, buckles, ragged edges, and other defects.
   b. Minimum Thickness: 18 gauge (1.2 mm).

2. Stainless Steel:
   a. Type 316, ASTM 240, with exposed surfaces ground and polished to a No. 4 finish.
   b. Minimum Thickness: 16 gauge (1.6 mm).
   c. Welding: All stainless steel welding material shall be of similar type to sheet material. Welds shall be made without discoloration, ground, polished, and passivated to blend with a No. 4 finish.

3. Liner and Baffle:
a. Typical: Glass-reinforced polyester panel, flame-retardant and self-extinguishing with smooth finish and white color. Flexural strength: 14,000 psi. Flame spread index of 0-25 when tested per UL 723 and ASTM E 84. Baffle shall be same material as liner. Liner thickness: 3/16 inch (4.76 mm); baffle thickness: ¼ inch (6.35 mm), minimum. Liner performance characteristics shall be as specified below.

4. Glass: 7/32 inch (5.56 mm) laminated safety glass. Glass shall not be etched with manufacturer’s name, logo, or any other permanent markings, other than to identify the glass as safety glass. Light fixture lens may be tempered safety glass.

5. Sash guides: Extruded PVC.

   a. Pulley assembly for sash chain: Finish bored steel drive sprockets and keyed drive, 1/2-inch (12.7 mm) diameter front connector shaft. Rear idler sprockets; double sealed ball bearings type, lubricated. All sprockets steel with zinc dichromate finish.

7. Sash belt: Two 1/2 inch wide stainless steel-reinforced polyurethane notched belts. Minimum tension cord strength of 840 N.
   a. Pulley assembly for sash belt: Cast aluminum sprocket mated to a steel shaft.

8. Sash pull: Steel with chemical resistant powder coating.
   a. Length: Full width of sash.

9. Gaskets: Provide PVC gasket at interior access panels to eliminate air leakage and retain liquids inside hood.

10. Fasteners:
   a. Exterior structural member attachments: Sheet metal screws, zinc plated.
   b. Interior fastening devices shall be concealed; exposed screws are not acceptable. Screw head caps are not acceptable.
   c. Exposed exterior fastening devices shall be corrosion-resistant, non-metallic material; exposed screws are not acceptable.

D. Construction:

1. Design: Fume hoods shall be designed for consistent and safe air flow through the hood face opening. Variations of face velocity shall not exceed ±20% of the average face velocity at any designated measuring point.
   a. Refer to the Laboratory Equipment Exhaust Schedule on the Laboratory Furnishings drawings for the design face velocity requirements for each type of fume hood.

2. Superstructure: Rigid, self-supporting assembly of double wall construction, maximum 4 7/8 inch (124 mm) thick. Wall shall consist of a sheet steel outer shell and a corrosion resistant inner liner, and shall house and conceal steel framing members, attaching brackets and remote operating service fixture mechanisms and services. Panels shall be attached to a full frame construction, minimum 14 gauge (2.0 mm) galvanized members. Panels and brackets attached to eliminate screw heads and metallic bracketry from hood interior.

3. Access Panel: Access to fixture valves and piping concealed in wall shall be through flush access panels on the inside liner walls, or through removable front posts. Panels shall be secured with PVC extruded gasket, or tamperproof, epoxy-coated, countersunk flat head screws providing a tight fit. Hook and loop type attachments and panels held by gravity are not acceptable.
4. Downdraft bypass: Low resistant type, 18 gauge (1.27 mm) steel chamber; directional louvers are not acceptable. All bypass air shall enter top of bypass chamber and enter hood in a downflow direction. Chamber shall protect user from expelled particulate in the event of an adverse internal reaction.

5. Baffles: Baffles shall be fixed and non-adjustable.

6. Ceiling Closure Panels: Panel shall include simple-to-operate means of access to the hood lighting fixture without the use of tools. Finish shall match superstructure exterior. Closure panel shall conceal view of the sash when the sash is in the open position. Provide sash pocket if required to allow correct operation of the bypass.
   a. Provide 18 gauge steel paneled enclosure from top of hood to 2 inches above the ceiling.

7. Trim and Side Panels: Provide matching steel trim and side panels, as required, to finish any openings around and between hoods. Panels shall be flush with other hood panels, and finish shall match superstructure exterior. At locations where fume hoods are back-to-back, provide one of the following:

8. Finished Back: Provide for any fume hood where back of hood is exposed to view. 18 gauge steel sheet. Finish shall match superstructure exterior.

9. Bypass Grille: Low-resistant type 18 gauge steel with upward directional louvers.

10. Exhaust Duct Collar:
   a. Construction: Provide Type 316L stainless steel, minimum 18-gauge, duct collar with 1 ½ inch (38 mm) to 2 inch (50 mm) extension above top of fume hood with butt joint termination suitable for welding. Duct collar design shall be bell-mouthed for round or contoured design for rectangular to provide lower static pressure drop and improved noise performance. Duct collar shall be integral to fume hood construction, factory-installed, and welded or permanently sealed airtight to hood.
   b. Configuration: For collar size and quantity, refer to Laboratory Equipment Exhaust Schedule on the Laboratory Furnishing drawings.

11. Exhaust Duct Transition Piece: Furnished by the fume hood manufacturer for installation by the mechanical contractor. Provide contoured Type 316L stainless steel, minimum 18 gauge, exhaust duct transition piece to connect to the fume hood exhaust duct collar and Laboratory exhaust duct system as shown on the Mechanical Drawings. Provide butt joint terminations suitable for welding. Note: Transition Piece is not required where hood exhaust duct collar has been provided per the Laboratory Equipment Exhaust Schedule.

12. Cup Sink:

13. Piping shall be as specified in Division 22 for respective system.

14. Service Fittings: As shown on Laboratory Furnishings Drawings and specified in Section 115343, factory-installed and complete with all gaskets, grommets and sleeves. No additional holes in fume hood side posts shall be provided for services beyond those required by the construction documents.

15. Alarm: Coordinate cut out for fume hood alarm to be provided under Division 23. All cut outs for alarm shall be made in the factory; field cutting is not acceptable.
   a. Locate at 48 inches or below for all Accessible designated fume hoods.

16. Electrical:
   a. Pre-Wiring: All fume hood electrical devices shall be factory-installed and wired to a junction box located on top of the hood. Comply with Division 26 requirements for electrical work.
      1). Fume hood receptacles shall be wired such that no more than two duplex outlets and the hood lighting are wired through a single circuit.
   b. Receptacles: Flush mounted, 125V / 20A / 60Hz duplex type, single gang, NEMA 5-20R, 3-wire, grounding type receptacle, one or two per side, or as indicated on
the Laboratory Furnishings Drawings, with brushed stainless steel cover plate. Each side of the fume hood shall have a GFCI receptacle with feed-through protection of any downstream receptacles.

17. Interior Hood Lighting:
   a. Lighting within the hood shall be provided by a UL approved, vapor-proof, LED light fixture operated by an exterior switch with a stainless steel cover plate. LED light color shall be 3,000K to 3,500K. Light fixture shall be approved for recessed and enclosed spaces, and third-party tested to 50,000 hours.
   b. Provide 1/4 inch thick safety glass panel cemented and sealed to the hood roof.
   c. Light level: Average light level on the work surface shall be 80 foot-candles, minimum.

18. Safety label: Provide self-adhesive polyester label, as described on the Laboratory Furnishings drawings. Labels shall indicate safe operating conditions with respect to fume hood sash position. Labels solely indicating 100 fpm face velocity sash position are not acceptable.
   a. Manufacturer: Lab Safety Supply Inc., P.O. Box 1368, Janesville, WI 53547 Tel: 800 356-0783, Model No. 156.
   b. Approved custom label meeting all requirements.
   c. Approved substitution.

19. Hood Finish: As specified elsewhere in this Section.

20. Exterior Color: As selected by Architect from manufacturer's full color line and complying with finish requirements.

E. Bench Mounted Chemical Fume Hoods:

1. Style: General purpose.
   a. Subject to compliance with the requirements listed below, acceptable models include:
      2). Vanguard Fume Hood by BedcoLab Ltd.
      3). APEX-Air GP Series by CiF Lab Solutions L.P.
      4). Isolator Bench Fume Hood by ICIscientific Metal Products, Inc.
      6). Protector XL Benchtop Laboratory Hood by Labconco Corporation.

2. Exterior depth: 34 1/2 inches, maximum.

3. Interior depth: 23 1/2 inches clear at 1 inch above the work surface, minimum.

4. Design:
   a. Restricted bypass fume hoods for variable air volume or constant volume exhaust systems with airfoil. Bypass shall be sufficient in size to allow 25% flow with sash closed. Bypass must be achieved through low resistance opening at top of front lintel panel. Bypass shall be designed to provide a smooth down flow effect.
   b. Fume hoods shall be designed to operate safely at face velocities of 100 feet per minute (0.51 m/s) to 125 feet per minute (0.64 m/s).

5. Work Surface: 1 ¼ inch (32 mm) dished epoxy resin, in compliance with Section 115310 requirements.
   a. Color:
      1). Base Bid: Black
2). Add Alternate Bid: Graphite as manufactured by Durcon Laboratory Tops, Inc., or approved substitution.

6. Airfoil: The airfoil shall allow ample room for electrical hospital grade cords to fit beneath the airfoil. Sill must pivot forward to provide cord and trough access. Bottom horizontal foil shall provide nominal 1 inch (25.4 mm) bypass when sash is in the closed position. Bottom foil shall not be removable without use of special tools. Airfoil shall be steel with urethane or epoxy powder coating.
   a. Sill shall be rounded or chamfered on front edge with all right angle corners radiused or angled. The airfoil and sill shall be flush with the height of the work surface; airfoil sills that are not flush with the top plane of the work surface dish are not acceptable.

7. Fume hood sash (Vertical): Full-view, frameless type with clear, unobstructed, side-to-side view of fume hood interior and service fixture connections. Sash to have a 35 inch (890 mm), nominal, sight line.
   a. Sash Opening: Refer to the Laboratory Equipment Exhaust Schedule on the Laboratory Furnishings drawings for vertical access height clearance.
   b. Counter balance system: Single weight, counter balance system to prevent sash tilting and permit ease of operation at any point along full width pull. Maximum 7 pounds (3 kg) pull required to raise or lower sash throughout its full length of operating sash opening. Design system to hold sash at any position without creep and to prevent sash drop in the event of suspension system failure.
   c. Sash Opening: Refer to the Exhaust Equipment Schedule on the Laboratory Furnishings drawings for vertical access height clearance.
   d. Sash Stop: Design to stop the sash at the Design Operating Condition as shown on the Exhaust Equipment Schedule, with manual override.

1). Provide one of the following types of sash stops for all fume hoods:
   a). Corrosion-resistant, spring-loaded lever handle integrated with sash track and fume hood side post.
   b). Stainless steel spring-loaded barrel-bolt integrated with sash pull and provided with angled stainless steel strike plate.

8. Baffle screen: Provide a perforated stainless steel screen or mesh designed to block debris and light materials from going up behind the baffle and into the exhaust ductwork.

F. Finish Requirements

1. Preparation:
   a. After the units have been completely welded together and before finishing, they shall be given a pre-paint treatment to provide excellent adhesion of the finish to the metal and to aid in the prevention of corrosion. Physical and chemical cleaning of the metal shall be accomplished by washing with an alkaline cleaner, followed by a spray treatment with a heated cleaner/phosphate solution and pretreated with iron phosphate spray followed by a neutral final seal prior to application of final finish. The strength of each solution shall be monitored by filtration to insure consistent quality.
   b. All treated parts shall be immediately dried in heated ovens and gradually cooled before application of the finish. Treated metal parts shall be clean and properly prepared to provide optimum adhesion of finish and resistance to corrosion.

2. Application: Electrostatically apply powder coat of selected color and bake in controlled high temperature oven to assure a smooth, hard satin finish. Surfaces shall have a chemical resistant, high grade laboratory furniture quality finish of the following thicknesses:
a. All surfaces, exterior or interior, exposed to view, shall receive sufficient powder coat to achieve an average 1.5 mil (38 µm) film thickness with a minimum 1.2 mil (30 µm) film thickness and shall have smooth satin luster.
b. Backs of cabinets and other surfaces not exposed to view shall have sufficient powder coat to achieve an average 1.0 mil (25 µm) film thickness.
c. Concealed interior parts shall receive corrosion-resistant treatment.
d. Stainless steel parts and surfaces shall not be powder coated.

3. Chemical Resistance Finish Performance Requirements:
   a. Test Procedure: Apply 10 drops (approximately 0.5 cubic centimeters) of each reagent identified to the surface of the finished test panels laid flat and level on a horizontal surface. Ambient temperature: 68°F to 72°F (20°C to 22°C). After one hour flush away chemicals with cold water and wash surface with detergent and warm water at 150°F (65.5°C) and with alcohol to remove surface stains. Examine surface under 100 foot-candles (1076 lux) of illumination.
   b. Evaluation Ratings: Change in surface finish and function shall be described by the following ratings:

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No effect No detectable change in the material surface.</td>
</tr>
<tr>
<td>1</td>
<td>Excellent Slight detectable change in color or gloss but no change in function or life of the surface.</td>
</tr>
<tr>
<td>2</td>
<td>Good A clearly discernable change in color or gloss but no significant impairment of surface life or function.</td>
</tr>
<tr>
<td>3</td>
<td>Fair Objectionable change in appearance due to discoloration or etch, possibly resulting in deterioration of function over an extended period of time.</td>
</tr>
<tr>
<td>4</td>
<td>Failure Pitting, cratering, or erosion of the surface. Damage to film and loss of adhesion and film protection. Obvious and significant deterioration.</td>
</tr>
</tbody>
</table>

4. Performance requirements: Test results for powder coat finish shall equal or exceed the following:

<table>
<thead>
<tr>
<th>Reagent</th>
<th>% by weight</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic acid</td>
<td>50%</td>
<td>1</td>
</tr>
<tr>
<td>Acetic acid, glacial</td>
<td>98%</td>
<td>1</td>
</tr>
<tr>
<td>Acetone</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>Ammonium hydroxide</td>
<td>25%</td>
<td>1</td>
</tr>
<tr>
<td>Amyl acetate</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Butyl alcohol</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Cresol</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Dimethyl formamide</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Dioxane</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Ethyl alcohol</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Ethyl ether</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Furfural</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Glycerin</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>10%</td>
<td>1</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>20%</td>
<td>1</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>37%</td>
<td>1</td>
</tr>
</tbody>
</table>
Reagent % by weight Rating

<table>
<thead>
<tr>
<th>Reagent</th>
<th>% by weight</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrofluoric acid</td>
<td>48%</td>
<td>2</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>30%</td>
<td>1</td>
</tr>
<tr>
<td>Kerosene</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Methyl alcohol</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Methyl ethyl ketone</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Monochlorobenzene</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Naphthalene (dissolved in Toulene)</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Nitric acid</td>
<td>10%</td>
<td>1</td>
</tr>
<tr>
<td>Nitric acid</td>
<td>30%</td>
<td>1</td>
</tr>
<tr>
<td>Phenol</td>
<td>85%</td>
<td>2</td>
</tr>
<tr>
<td>Phosphoric acid</td>
<td>25%</td>
<td>1</td>
</tr>
<tr>
<td>Phosphoric acid</td>
<td>75%</td>
<td>1</td>
</tr>
<tr>
<td>Potassium hydroxide</td>
<td>45%</td>
<td>1</td>
</tr>
<tr>
<td>Silver nitrate (10% aqueous solution)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Sodium carbonate, saturated</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Sodium chloride, saturated</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>40%</td>
<td>1</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>50%</td>
<td>1</td>
</tr>
<tr>
<td>Sodium hypochlorite</td>
<td>5.25%</td>
<td>1</td>
</tr>
<tr>
<td>Sodium sulfide, saturated</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Sulfuric acid</td>
<td>50%</td>
<td>1</td>
</tr>
<tr>
<td>Sulfuric acid</td>
<td>70%</td>
<td>1</td>
</tr>
<tr>
<td>Tincture of Iodine</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Toulene</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Xylene</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Zinc chloride, saturated</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Maximum concentration is to be understood unless a lower concentration is shown in the table.

a. Physical Tests:

1. Abrasion: Finish shall have high abrasion resistance with maximum weight loss of 5.5 mg per 100 cycles as tested on a Taber Abrasion Tester No. E40101 with 1000 gm wheel pressure and Calibrase No. CS10 wheel.

2. Hardness: Finish shall have surface hardness equivalent to 4H or 5H pencil lead.

3. Humidity: Finish shall withstand 1000 hours exposure in saturated atmosphere at 100°F (38°C).

4. Moisture: Finish shall withstand the following procedures with no visible effect:
   a) Boiling water flowing over 45 degree inclined surface for 5 minutes.
   b) 100 hours continuous contact with water-soaked cellulose sponge, maintained in a wet condition throughout test.

5. Adhesion: Finish shall withstand the following test procedure with at least 95 squares maintaining their finish. Using a razor blade, score the finish surface of the test panel through to the substrate with a pattern of 100 squares, each 1/16 inch x 1/16 inch. Brush away loose particles with a soft brush.


G. Fume Hood Liner Test: Polyresin

1. Test No. 1: Spills and Splashes:
a. Suspend a 42 inches (1067 mm) x 12 inches (305 mm) panel (42 inch (1067 mm) dimension horizontal) in a position to expose the surface to be tested in a vertical plane. Divide the panel vertically into 3/4 inch (19 mm) spaces.

b. Using an eyedropper, apply five drops of each reagent as listed.

c. Liquid reagents shall be applied at the top of the panel and permitted to flow down full panel height. (CAUTION! Flush away any reagent drops.)

2. Test No. 2: Fumes and Gases:

a. Prepare a panel 24 inches (610 mm) x 12 inches (305 mm) by dividing panel into 2 inch (51 mm) squares. Using 100 ml beakers, place 25 ml (approximately 1/2 inch (13 mm) of reagent) into each beaker. Place beakers in position so that test panel may be placed over beaker tops in the proper sequence. Place panel over beakers. Note: Beaker pouring lip permits atmospheric oxygen to enter and participate in the reaction of the reagent fumes.

b. After a 24 hour time period has elapsed, remove panel, flush off with water, clean with naphtha and detergent, rinse and wipe dry. Evaluate.

3. Evaluating Ratings:

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No effect (No detectable change in the material surface.)</td>
</tr>
<tr>
<td>1</td>
<td>Excellent (Slight detectable change in color or gloss but no change in function or life of the surface.)</td>
</tr>
<tr>
<td>2</td>
<td>Good (A clearly discernable change in color or gloss but no significant impairment of surface life or function.)</td>
</tr>
<tr>
<td>3</td>
<td>Fair (Objectionable change in appearance due to discoloration or etch, possibly resulting in deterioration of function over an extended period of time.)</td>
</tr>
<tr>
<td>4</td>
<td>Failure (Pitting, cratering, or erosion of the surface. Obvious and significant deterioration.)</td>
</tr>
</tbody>
</table>

4. Performance: Test results shall equal or exceed the following:

<table>
<thead>
<tr>
<th>Reagent</th>
<th>% by wt.</th>
<th>Spills</th>
<th>Fumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic acid, glacial</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Acetone</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Acid dichromate</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Ammonium hydroxide</td>
<td>28%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Amyl acetate</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Benzene</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Butyl alcohol</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chloroform</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chromic acid, saturated</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cresol</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dichloro acetic acid</td>
<td>93%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dimethyl formamide</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dioxane</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ethyl alcohol</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ethyl ether</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>37%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Formic Acid</td>
<td>88%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Furfural</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gasoline</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hydrochloric acid</td>
<td>48%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hydrofluoric acid</td>
<td>37%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>30%</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
2.3 FUME EXTRACTOR ARMS (SNORKELS)

A. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be provided by a single manufacturer.

1. Alsident System represented by Laboratory Enterprises, 3122 Brinkerhoff Road, Kansas City, KS 66115 Tel: 913 621-7337.
4. Approved substitution.

B. Models: Subject to compliance with the requirements listed below, acceptable models include:

1. System 75 by Alsident System.
2. MET by Movex.
3. FX Extractor Arms by Nederman Inc.

C. Type: Ceiling mounted, self-supporting fume extractor arm.

D. Characteristics:

1. Extractor Arm Diameter:
   a. 3 inch diameter tubes.

2. Extractor Arm Material:
a. Anodized aluminum.

3. Arm Length: Arms shall be of sufficient length to cover an 18 inch radius area at 48 inches above the finished floor.
   a. Assembly shall be positioned so that no component is lower than 90 inches above the finished floor.

4. Swivel Assembly: Hi-grade cast aluminum with 360 degree rotation.
   a. Provide external, corrosion-resistant adjustment knobs.
   b. Gas Spring: Provide gas spring to support upper friction joint to provide stable positioning of articulated snorkel arm.

7. Ceiling mounted stanchion/bracket for attachment to structure above.
8. Escutcheon suitable to trim any ceiling penetrations.
9. Final connection to the fume exhaust duct system under Division 23. Provide airflow per Equipment Exhaust Schedule.
10. Dampers are not acceptable and shall not be provided.

2.4 FUME EXTRACTOR ARMS (SNORKELS): HIGH TEMPERATURE

A. Manufacturers: Products complying with this specification may be provided by the following manufacturers. All products specified in this section shall be provided by a single manufacturer.
   2. Approved substitution.

B. Basis of design: Movex, Mex-AA. 4 inch (100 mm) diameter, stainless steel, telescopic air extractor assembly for atomic absorption equipment, or equivalent.
   1. Telescopic assembly:
      b. Dimensions: 42 inch long extractor assembly, with a 17 inch telescopic extension.
   2. Wall mounting bracket: Powder coated steel support with 180 degree swing motion. Arm length shall be provided with a 10 inch adjustment from 14 inches to 24 inches from the wall.
   4. Hood: 10 inch diameter, 316L stainless steel.
   5. Flexible Hose: Provide a 60 inch long, 5 inch diameter hose for connection to the building exhaust system. Provide two draw-band clamps. Modify hose length as required for the ceiling height.
      1) Heat resistance: Capable of withstanding up to 570 degrees F.
   6. Final connection to the fume exhaust duct system under Division 23. Provide airflow per Equipment Exhaust Schedule.
2.5 CANOPY HOODS

A. Custom fabricated stainless steel canopy hoods: Refer to Section 115310, Stainless Steel Fabrications.

PART 3 - EXECUTION

3.1 SITE CONDITIONS

A. Prior to installation of the Work of this Section, carefully inspect the installed Work specified in other sections and verify that all such Work is complete to the point where this installation may properly commence.

B. Verify that all Work has been installed in complete accordance with the original design, received submittals, and the manufacturer's recommendations.

C. In the event of discrepancy, immediately notify the Architect. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.2 INSTALLATION

A. Work in this Section requires close coordination with Work specified in Division 22, Division 23 and Division 26, as well as installation by Owner of Owner furnished components. Coordinate all Work to ensure an orderly process in the Project, without removal of previously installed Work, and so as to prevent damage to finishes and products.

B. Coordinate location and alignment of fume hoods and cabinets for proper connection of all piping and duct work.

C. Install all equipment in accordance with applicable codes and regulations, accepted Shop Drawings, and as necessary for a complete operating system.

3.3 FIELD TESTING

A. Chemical Fume Hoods:
   1. Fume hood field tests shall be performed by a qualified independent testing company on each hood.
   2. All laboratory supply, general exhaust, and fume exhaust HVAC systems shall be operational during testing.
   3. Test and certify each fume hood in accordance with ASHRAE Standard 110-2016 for Section 6.1 Flow Visualization, Section 6.2 Face Velocity Measurements, Section 6.3 Test Method for VAV Fume Hoods, Section 6.4 VAV Response Test, and Section 7 Tracer Gas Test Procedure testing requirements.
   4. Flow Visualization: Fume hood shall provide complete containment of the smoke generated within the hood.
   5. Face Velocity Measurements: Fume hoods shall be tested at the design operating condition sash opening height indicated in the Chemical Fume Hood Schedule.
      a. Fume hoods shall achieve the scheduled design operating condition average face velocity within ±5 fpm.
b. Individual face velocity readings shall not vary by more than 20% of the mean between measurement grid locations.

6. Test Method for VAV Fume Hoods (Not Applicable to CAV Hoods): Perform this test to confirm VAV controls are properly calibrated. Average and individual face velocity reading should meet the performance criteria indicated for Section 6.2 Face Velocity Measurements above.

7. VAV Response Test (Not Applicable to CAV Hoods): Perform this test to verify VAV controls are responding accurately to the opening of the fume hood sash. The time it takes from the start of the sash movement until the face velocity stabilizes shall be less than 5 seconds.

8. Tracer Gas Test Procedure: Fume hoods shall achieve an As-Installed (AI) performance rating equal or better than 0.10 ppm with 4.0 Lpm tracer gas release rate.

9. Cross Drafts: Fume hood testing shall also include measuring and documenting the vertical and horizontal cross-drafts at the face of the hood. Cross-drafts shall not exceed half of the fume hood face velocity.

10. Balancing of the HVAC systems is in the scope of work of Division 23.

3.4 CLEANING AND PROTECTION

A. Repair or remove and replace defective work as approved by the Architect upon completion of installation.

B. Adjust all moving or operating part to function within their design parameters.

C. Clean equipment, touch up as required.

D. Protect all units before, during, and after installation. Damaged materials due to improper protection shall be cause for rejection.

END OF SECTION
SECTION 115343 - LABORATORY SERVICE FITTINGS AND FIXTURES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Laboratory service fittings, valves, and related components.

B. Laboratory emergency plumbing fixtures.

C. Laboratory sink units.

1.2 RELATED SECTIONS

A. Division 22: Plumbing

B. Section 222000: Laboratory Plumbing

C. Division 23: Heating, Ventilated, and Air Conditioning (HVAC)

D. Division 26: Electrical

1.3 REFERENCES


1.4 DESCRIPTION

A. Work includes but is not necessarily limited to furnishing to the project site for installation by Division 22, all laboratory fixtures, fittings, and emergency plumbing fixtures described herein and shown on the Laboratory Furnishings Drawings.

1.5 SUBMITTALS

A. Refer to General Conditions and Division 1 “Submittal Procedures” for submittal requirements. In addition to these requirements, provide submittal requirements specified herein.

B. Submittal requirements:

1. Submittal shall be prepared individually for this specification section. Arrange product data, drawings and information for submission in a complete set for this specification section.

2. Submittal shall contain complete data for all items of this specification section. Periodic or partial submittals of individual components within this specification section will be returned as incomplete and rejected.

3. Submittals shall be organized by specification sequence with section and paragraph number identified.
4. Equipment and components being proposed shall be clearly labeled with all options and accessories indicated and shall be for this specific project.

C. Materials List/Product Data: Submit complete materials list, including catalogue data, of all materials, equipment, and products for Work in this Section.

D. Shop Drawings: Submit complete shop fabrication and installation drawings, including plans, elevations, sections, details and schedules. Show relationship to adjoining materials and construction. Shop Drawings shall be in the form of reproducibles or photocopies, not to exceed 11 inches by 17 inches (A3) in size. Blueline prints are not acceptable.

E. Approved Substitution/Approved Equal: In addition to the items required in Division 1, all substitution requests shall include item-by-item comparison of the proposed substitution to this project specification. A copy of the project specification shall be submitted, with each item and subsection of the project specification marked as “Comply” or “Not Comply.” In any cases where “Not Comply” is indicated, an explanation of the relative advantages of the proposed design shall be provided.

1. Substitution shall not affect dimensions shown on Drawings.
2. The Contractor shall pay for changes to the building design, including engineering design, detailing, utility and service requirements, and construction costs caused by the requested substitution.
3. Substitutions shall have no adverse effect on other trades, the construction schedule, or specified warranty requirements.
4. Maintenance and service parts shall be locally available for the proposed substitution.

F. Samples: Submit two (2) samples of each type of specified finish and color specified.

G. Certifications: As a condition of acceptance, submit certification stating that equipment is complete and ready for intended function.

H. Operations/Maintenance Manuals: Accompanying certification, submit for Architect’s review and Owner’s use, complete operating and maintenance manuals that describe proper operating procedures, maintenance and replacement schedules, components parts list, and closest factory representative for components and service.

1.6 PRODUCT HANDLING

A. Protection: Use all means necessary to protect work of this section before, during and after installation including installed work and materials of other trades.

B. Replacement: Any damaged work shall be replaced, repaired and restored to original condition to the approval of the Architect at no additional cost or inconvenience to the Owner.

1.7 QUALIFICATIONS

A. Work in this section shall be performed by a company having a minimum of eight years documented experience, and an established organization and production facilities including all tools, equipment and special machinery necessary for specializing in the fabrication and installation of the type of equipment required, with skilled personnel, factory trained workmen and an experienced engineering department. Each shall have the demonstrated knowledge, ability and the proven capability to produce the specified equipment of the required quality and
the proven capacity to complete an installation of this size and type within the required time limits.

B. Work in this Section requires close coordination with Work in electrical and mechanical Sections. Coordinate all Work to assure an orderly progress in the Project, without removal of previously installed Work, and so as to prevent damage to finishes and products.

C. Review conditions of installation, procedures and coordination with related Work.

D. Carefully inspect the installed Work specified in other Sections and verify that all such Work is complete and ready for the installation of this Work to properly commence.

E. Verify that all Work may be installed in complete accordance with the original design, reviewed submittals and manufacturer's recommendations.

1.8 WARRANTY

A. All products will be warranted to be free from defects in materials and workmanship for a period of one year following substantial completion. The manufacturer/dealer/subcontractor shall repair or replace any products (or parts thereof) that are found to be defective. Replacement will include any parts, labor, shipping, and travel expenses involved. Warranty replacement work must be scheduled in coordination with the Owner's academic/research schedule, and may therefore require evening and/or weekend work.

PART 2 - PRODUCTS

2.1 GENERAL

A. All service fittings and emergency plumbing fixtures shall be specifically designed for laboratory use.

B. Service fittings, emergency fixtures, sinks, etc. specified in this Section shall be furnished and delivered to point of use for installation as specified in Division 22.

C. All service fittings shall be factory pre-assembled including the assembly of valves to turrets, mounting shanks to turrets, etc., and individually factory tested.

D. All laboratory service fittings shall be the product of one service fitting manufacturer to assure ease of replacement and maintenance.

E. All service valves, fittings, turrets, flange and accessories shall be forged brass with a minimum copper content of 85%.

F. Provide fittings as shown in laboratory fitting details for all laboratory equipment at locations shown on the Laboratory Furnishings drawings. See Service Fitting Schedule.

G. Assembly components and operating parts such as valve stems, renewable units, packing nuts, outlet nozzles and straight serrated hose ends shall be made from solid brass stock.

H. Replaceable seats, needle cones, valve disc screws and other accessories shall be Monel or stainless steel alloys especially selected for use intended.
I. Fittings shall be factory tested and shall be supplied with nipples, lock nuts, shanks, etc.

J. Serrated tip fittings shall be threaded with the hose end being tapered.

K. Turrets shall be brass drop forging of design indicated in details shown elsewhere in the Section and shall be one or two-way, as required, with 3/8 inch (9.525 mm) IPS female inlet thread for connections. Units shall be furnished with brass shanks, brass locknuts, and washers.

L. Fittings located on the same plane shall have their handles project the same distance from the plane of reference to present a uniform related appearance, regardless of valve type construction.

M. Flanges shall be brass forging of approved design with 3/8 inch (9.525 mm) IPS female inlet and outlet.

N. All goosenecks shall provide full thread for attachment of aerator or serrated hose ends.

O. Hot water/cold water gooseneck mixers and wall-mounted cold water goosenecks shall swivel. Swivel point shall be above valve body or at valve level if wall mounted. Swing joints shall have heavy Teflon type packings; "0" rings will not be permitted. Cold water goosenecks at cup sinks shall be rigid.

P. All fittings shall have plastic colored service index buttons as specified in this Section.

Q. Provide approved backflow preventers at hand held drench hoses. See details on Laboratory Furnishings drawings.

R. Provide durable 1 inch x 3 inch (25 x 75 mm) sign "NONPOTABLE WATER, DO NOT DRINK" at each bench mounted industrial water fitting, see details on Laboratory Furnishings drawings.

S. Fittings and fixtures designated to be accessible to persons with disabilities (ADA) with operable parts shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate operable parts shall be 5 pounds (22.2 N), maximum.

2.2 LABORATORY SERVICE FITTINGS

A. Manufacturers:

1. Products, which comply with this specification section as judged and approved by the Architect, may be provided by the following manufacturers. All products specified in this section shall be provided by a single manufacturer.

   a. Water Saver Faucet Co., 701 West Erie Street, Chicago, IL 60610 Tel: 312 666-5500.
   b. T&S Brass and Bronze Works, Inc., 2 Saddleback Cove, P. O. Box 1088, Travelers Rest, SC 29690 Tel: 800 476-4103.
   c. Broen-Lab, Inc., 15 Constitution Dr., Ste. 122, Bedford, NH 03110 Tel: 603 310-5088.
   d. Approved substitution.

B. Cylindrical Pattern:

1. All service fittings shall have WaterSaver Standard turret style (not ColorTech) as the basis of design.
C. Handles:

1. Faucets designated to be accessible to persons with disabilities (ADA): provide 4 inch "wrist-blade" handles with color coded screw-on index (identification) discs. Wrist-blade handles to be installed in the vertical position (off).
2. Laboratory air and vacuum valves at workstations indicated to be accessible to persons with disabilities (ADA) and all laboratory gas valves: Provide ball valves fitted with lever-type handles and color coded screw-on index (identification) discs.
3. Other fittings shall be fitted with four arm handles and color coded screw-on index discs.

D. Finish: As described elsewhere in this section.

E. Water Valves:

1. Water valves shall include a renewable unit containing all the working parts which are subject to wear, including stainless steel or monel seat, monel screw and heavy duty seat disk and Teflon packing.
2. Volume control at deck mounted water faucets:
   a. Compression unit with integral adjustable volume control to regulate size of inlet port of valve.
   b. 3/8 inch NPS male inlet aerator with flow control inserts.
3. Volume control at fume hood water outlets: Serrated hose end shall have a 0.5 GPM removable flow restrictor insert to allow a perfect flow out of the outlet and eliminate any splashing or wide pattern spray.
4. Goosenecks: Unit shall be capable of being readily converted from compression to self-closing, and vice versa, without disturbing faucet body and shall also be capable of being readily converted from water construction to needle valve or steam valve construction having outside packing gland without disturbing faucet body.
5. Unit shall be sealed in valve body with special composition gasket. Metal-to-metal or ground joint type of sealing is not acceptable.
6. Water fixtures shall be fully assembled and factory tested at 80 psi (0.55 MPa) water pressure.

F. Needle Valves: Fully assembled and factory tested at 225 psi (1.55 MPa) air pressure. Gas, air, vacuum and steam needle valve fittings shall have stainless steel replaceable floating cone that is precision ground and self-centering which shall seat against a stainless steel or monel renewable valve seat. Action of valve shall be slow compression for fine control under pressure up to 150 psi (1.03 MPa) and shall have subject-to-wear parts easily replaceable. Provide pressure regulators designed for use with the appropriate service at locations indicated on the Laboratory Furnishing drawings. Needle valves for fuel (laboratory) gas service shall be certified for use with fuel gas by the Canadian Standards Association under ANSI Z21.15-2009/CGA 9.1-2009. Needle valves in fume hoods shall be mounted on the front panel of the fume hood, with all components subject to wear accessible from the exterior face of the hood.

G. Laboratory Ball Valves: Suitable for laboratory gas, air and vacuum and be supplied fully assembled and factory tested at 125 psi (0.86 MPa) air pressure. Ball valves shall be of quarter-turn (closed to fully open) design, be fitted with lever handle requiring less than 5 lbf (22 N) force to operate, and shall have subject-to-wear parts easily replaceable. Ball valves for fuel (laboratory) gas service shall be certified for use with fuel gas by the Canadian Standards Association under ANSI Z21.15-2009/CGA 9.1-2009.

H. High Purity Water Valves: Suitable for purified water and provided with polypropylene liner. Valve stem and bonnet shall be brass.
I. Service Fitting Color Index:

<table>
<thead>
<tr>
<th>Service Name</th>
<th>Disc Color</th>
<th>Letters</th>
<th>Letter Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory Gas</td>
<td>Dark Blue</td>
<td>GAS</td>
<td>White</td>
</tr>
<tr>
<td>Laboratory Vacuum</td>
<td>Yellow</td>
<td>VAC</td>
<td>Black</td>
</tr>
<tr>
<td>Industrial Cold Water</td>
<td>Dark Green</td>
<td>ICW</td>
<td>White</td>
</tr>
<tr>
<td>Industrial Hot Water</td>
<td>Red</td>
<td>IHW</td>
<td>White</td>
</tr>
<tr>
<td>Purified Water</td>
<td>White</td>
<td>PW</td>
<td>Black</td>
</tr>
<tr>
<td>Deionized Water</td>
<td>White</td>
<td>DI</td>
<td>Black</td>
</tr>
</tbody>
</table>

2.3 LABORATORY EMERGENCY PLUMBING FIXTURES

A. Manufacturers:
   1. Products, which comply with this specification section as judged and approved by the Architect, may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.
      a. Water Saver Faucet Co., 701 West Erie Street, Chicago, IL 60610 Tel: 312 666-5500.
      b. Guardian Equipment, 1104N North Branch St., Chicago, IL 60642 Tel: 312 447-8100.
      c. Haws Corporation, 1455 Kleppe Lane, Sparks, NV 89431 Tel: 775 359-4712.
      d. Approved substitution.


C. All emergency plumbing fixtures shall be accessible to persons with disabilities in compliance with the requirements of the federal Americans with Disabilities Act (ADA), ADA Accessibility Guidelines (ADAAG), and state accessibility regulations.

D. Barrier-free safety station with emergency shower actuation valve in stainless steel cabinet for recess mounting and wall-mounted eyewash with stainless steel skirt: Water Saver Model No. SSBF670-721, or equal, with the following characteristics or modifications.
   1. Ceiling-mounted exposed showerhead. Nipple length shall be as required for a complete installation; verify finished ceiling height.
   2. Exposed piping, showerhead, nipple, and escutcheon shall be chrome-plated brass with clear epoxy coating.
   3. Safety shower actuating arm shall be stainless steel.
   4. Showerhead shall have perforated stainless steel spreader.
   5. Safety shower actuating arm shall be mounted in a flanged, recessed-mounted 18 gauge (1.3 mm) stainless steel cabinet with No. 4 finish.
   6. Flag/paddle shall be epoxy-coated cast aluminum or stainless steel.
   7. Eyewash heads shall be ABS plastic with float-off dust covers.
   8. Stainless steel skirt shall have No. 4 finish.
   10. Fixture shall be furnished with green plastic sign with graphic symbol for safety shower/eyewash.
E. Barrier-free safety station with swing-down eye/face wash, drain pan and emergency shower actuation valve in stainless steel cabinet for recessed mounting: Water Saver Model No. SSBF2150, or equal, with the following characteristics or modifications.

1. Ceiling-mounted exposed showerhead. Nipple length shall be as required for a complete installation; verify finished ceiling height.
2. Exposed piping, showerhead, nipple, and escutcheon shall be chrome-plated brass with clear epoxy coating.
3. Safety shower actuating arm shall be stainless steel.
4. Showerhead shall have perforated stainless steel spreader.
5. Eyewash heads shall be ABS plastic.
6. Eyewash flow shall be activated by swing-down actuation valve connected to eyewash piping.
7. Eyewash components and safety shower actuating arm shall be mounted in a flanged, recessed-mounted 18 gauge (1.3 mm) stainless steel cabinet with No. 4 finish. A stainless steel drain pan shall be integral with eyewash components and shall direct eyewash water to drain outlet in bottom of recessed mounting cabinet.
8. Stay-open brass ball valves concealed behind stainless steel/access panel housing.
9. Fixture shall be furnished with green plastic sign with graphic symbol for safety shower/eyewash.


1. Must be barrier free with supply arm angled downward so that spray heads are no more than 36 inches above finished floor in the down position.
2. Straight supply arm not meeting barrier free requirements is not acceptable and shall not be provided.
3. Coordinate configuration and location with other adjacent services.
4. Swing-down eye wash unit with dual gentle spray outlet heads and “AutoFlow” feature.
5. Heads shall be equipped with flip top dust cover that automatically releases with water pressure.
6. Furnish with inline backflow preventer at the inlet.
7. Strainer: Provide inline strainer to protect valve and spray heads.
8. Arm and elbow fitting shall be chrome-plated brass with clear epoxy coating.
9. Housing enclosure shall be stainless steel, Type 316.
10. Mounting shank.
11. Fixture shall be furnished with green plastic sign with graphic symbol for eyewash.

2.4 FINISHES

A. Service Fittings:

1. Polished chrome finish with clear, acid-resistant coating:
   a. Chrome finish: All exposed surfaces shall be polished and buffed, then electroplated with one layer of nickel and one layer of chrome. Each layer of plating shall completely cover all visible areas. Total plating thickness shall be not less than 0.4 mil (10 µm).
   b. Clear epoxy coating: Following plating, clear epoxy coating shall be applied to all exposed surfaces and then baked to permit curing. Surfaces shall have a minimum coating thickness of 2 mils (50 µm).

B. Service Fittings at Fume Hoods:
1. Preparation: Surfaces to be coated shall be polished or sandblasted to produce a uniform fine-grained surface and immersed in a phosphoric acid cleaning solution to remove thoroughly all oil, grease and other foreign substances.

2. Epoxy finish: Following cleaning, coating material shall be electrostatically applied to all exposed surfaces. After application, coating shall be fully baked to permit curing. Coating material shall be free-flowing epoxy powder with particle size of 1.4 to 2.8 mils (35 to 70 µm). Surfaces shall have a minimum finished coating thickness of 2 mils (50 µm).

3. Color:
   a. Fittings inside fume hoods shall have a colored finish color-coded to match the fitting service index color.

C. Performance requirements for coated finishes:

1. Chemical resistance:
   a. Fume Test: Suspend coated samples in a container of at least 6 cu. foot (170 L) capacity, approximately 12 inches (300 mm) above open beakers, each containing 100 mL of 70% nitric acid, 94% sulfuric acid and 35% hydrochloric acid, respectively. After exposure to these fumes for 150 hours, the finish on the samples shall show no discoloration, disintegration or other effects.
   b. Direct Application Test: Subject coated samples to the direct action of the following reagents and solvents at a temperature of 25°C dropping from a burette at the rate of 60 drops per minute for ten minutes. Finish on samples shall not rupture, though slight discoloration or temporary softening is permissible.

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic Acid</td>
<td>98%</td>
</tr>
<tr>
<td>Acetone</td>
<td></td>
</tr>
<tr>
<td>Ammonium Hydroxide</td>
<td>28%</td>
</tr>
<tr>
<td>Amyl Acetate</td>
<td></td>
</tr>
<tr>
<td>Amyl Alcohol</td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td></td>
</tr>
<tr>
<td>Butyl Alcohol</td>
<td></td>
</tr>
<tr>
<td>Calcium Hypochlorite</td>
<td></td>
</tr>
<tr>
<td>Carbon Disulfide</td>
<td></td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td></td>
</tr>
<tr>
<td>Chromic Trioxide Acid</td>
<td></td>
</tr>
<tr>
<td>Cresol</td>
<td></td>
</tr>
<tr>
<td>Crude Oil</td>
<td></td>
</tr>
<tr>
<td>Dioxane</td>
<td></td>
</tr>
<tr>
<td>Distilled Water</td>
<td></td>
</tr>
<tr>
<td>Ether</td>
<td></td>
</tr>
<tr>
<td>Ethyl Acetate</td>
<td></td>
</tr>
<tr>
<td>Ethyl Alcohol</td>
<td></td>
</tr>
<tr>
<td>Ethyl Ether</td>
<td></td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>37%</td>
</tr>
<tr>
<td>Formic Acid</td>
<td>90%</td>
</tr>
<tr>
<td>Gasoline</td>
<td></td>
</tr>
<tr>
<td>Glacial Acetic Acid</td>
<td>99.5%</td>
</tr>
<tr>
<td>Glycerine</td>
<td></td>
</tr>
<tr>
<td>Hydrochloric Acid</td>
<td>38%</td>
</tr>
<tr>
<td>Hydrofluoric Acid</td>
<td>48%</td>
</tr>
<tr>
<td>Hydrogen Peroxide</td>
<td>5%</td>
</tr>
<tr>
<td>Isopropyl Alcohol</td>
<td></td>
</tr>
<tr>
<td>Lactic Acid</td>
<td>10%</td>
</tr>
<tr>
<td>Reagent</td>
<td>Concentration</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Kerosene</td>
<td></td>
</tr>
<tr>
<td>Methanol</td>
<td></td>
</tr>
<tr>
<td>Methyl Alcohol</td>
<td></td>
</tr>
<tr>
<td>Methyl Ethyl Ketone</td>
<td></td>
</tr>
<tr>
<td>Methylene Chloride</td>
<td></td>
</tr>
<tr>
<td>Mineral Oil</td>
<td></td>
</tr>
<tr>
<td>Monochlor Benzene</td>
<td></td>
</tr>
<tr>
<td>N-Hexane</td>
<td></td>
</tr>
<tr>
<td>Naphthalene</td>
<td></td>
</tr>
<tr>
<td>Nitric Acid</td>
<td>70%</td>
</tr>
<tr>
<td>Perchloric Acid</td>
<td>70%</td>
</tr>
<tr>
<td>Phenol</td>
<td></td>
</tr>
<tr>
<td>Phosphoric Acid</td>
<td>75%</td>
</tr>
<tr>
<td>Sea Water</td>
<td></td>
</tr>
<tr>
<td>Silver Nitrate</td>
<td>30%</td>
</tr>
<tr>
<td>Sodium Bichromate</td>
<td>Saturated</td>
</tr>
<tr>
<td>Sodium Carbonate</td>
<td>10%</td>
</tr>
<tr>
<td>Sodium Chloride</td>
<td>20%</td>
</tr>
<tr>
<td>Sodium Hydroxide</td>
<td>50%</td>
</tr>
<tr>
<td>Sodium Hypochlorite</td>
<td></td>
</tr>
<tr>
<td>Sodium Sulfide</td>
<td></td>
</tr>
<tr>
<td>Sulfuric Acid</td>
<td>87%</td>
</tr>
<tr>
<td>Toluene</td>
<td></td>
</tr>
<tr>
<td>Trichlorethylene</td>
<td></td>
</tr>
<tr>
<td>Turpentine</td>
<td></td>
</tr>
<tr>
<td>Urea</td>
<td>Saturated</td>
</tr>
<tr>
<td>Xylene</td>
<td></td>
</tr>
<tr>
<td>Zinc Chloride</td>
<td>Saturated</td>
</tr>
</tbody>
</table>

2. Mar and abrasion resistance: Coating material shall have a pencil hardness of 2H – 4H with adhesion substantial enough to withstand both direct and reverse impacts of 160 inch-pounds (18 Nm). Coating shall have excellent mar resistance and be capable of withstanding scuffing, marring and other ordinary wear.

3. Repairability: Scratches and other localized surface damage shall be field-repairable.

2.5 LABORATORY SINKS

A. Epoxy Resin:

1. Manufacturer: Manufacturer shall be the manufacturer of epoxy resin work surfaces specified in Section 115310.

2. Laboratory Sinks:

   a. Drop-in Type: Drop-in installation by Division 11 in epoxy resin work surface, sizes as indicated on drawings. Color to match work surface.

   b. Comply with the requirements of Section 115310 for epoxy resin.

   c. All exposed edges shall be radiused not less than 1/4 inch (6 mm).

   d. Tops without drain grooves: Sink shall be set 1/8 inch (3 mm) below the level of the adjacent surface.

   e. Provide epoxy resin sink outlet in color to match sink with strainer, stopper and open-end overflow, and install in sink with continuous bead of silicone sealant.

1) At black epoxy resin sinks, outlet shall be black polypropylene.
f. Provide tailpiece compatible with waste piping system for all sinks unless otherwise specified. Refer to Division 22 for piping requirements.

B. Stainless steel:
   1. Laboratory Sinks:
      a. Refer to Section 115310, Stainless Steel Fabrications.
      b. Provide stainless steel strainer, outlet, standpipe overflow and stopper for all sinks unless otherwise specified.
      c. Provide tailpipes compatible with waste piping system for all sinks unless otherwise specified. Refer to Division 22 for piping requirements.

PART 3 - EXECUTION

3.1 SITE CONDITIONS

A. Inspection:
   1. Prior to installation of fittings specified in Section 115343, carefully inspect the installed Work specified in other Sections and verify that all such Work is complete to the point where this installation may properly commence.
   2. Verify that all Work has been installed in complete accordance with the original design, approved submittals, and the manufacturer's recommendations.

B. Discrepancy:
   1. In the event of discrepancy, immediately notify the Architect.

3.2 PACKING AND DELIVERY

A. Deliver all fittings and fixtures to job site in recommended packaging, with each fitting individually packaged, marked, and scheduled for point of use.

B. Inventory fittings, at job site, verify that type and quantity are correct, and re-package until installed.

C. Store in clean, dry location.

3.3 INSTALLATION

A. Set internal volume control on all cup sink water fittings so that water does not splash out of sink.

B. Products to be installed in strict compliance with manufacturer's installation manuals and to comply with SEFA 2.

END OF SECTION
SECTION 115350 - LABORATORY EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Laboratory Glassware Washer/Dryers: Base Cabinet Height
B. Laboratory Sterilizers (Autoclaves): Small

1.2 RELATED SECTIONS

A. General and Supplementary Conditions and Division 1
B. Division 23: Mechanical
C. Division 22: Plumbing
D. Division 26: Electrical

1.3 REFERENCES

A. Comply with requirements of general and supplementary conditions and Division 1 as part of this specification.

1.4 DESCRIPTION

A. Furnish and install all laboratory equipment with necessary components and accessories required to ensure a complete installation and ready for intended use as specified herein and shown on the Laboratory Furnishings Drawings.
B. Provide side panels to cover all exposed sides of cabinet-type equipment designed for under-counter installation.
C. Work of this section requires close coordination with work of Division 22, 23 and 26 as well as installation of Owner furnished components and work specified in other Sections. Sequence all work to assure an orderly progress in the project without removal of previously installed work and so as to prevent damage to finishes and products.

1.5 SUBMITTALS

A. Refer to General Conditions and Division 1 “Submittal Procedures” for submittal requirements. In addition to these requirements, provide submittal requirements specified herein.
B. Submittal requirements:
   1. Submittal shall be prepared individually for this specification section. Arrange product data, drawings and information for submission in a complete set for this specification section.
2. Submittal shall contain complete data for all items of this specification section. Periodic or partial submittals of individual components within this specification section will be returned as incomplete and rejected.
3. Submittals shall be organized by specification sequence with section and paragraph number identified.
4. Equipment and components being proposed shall be clearly labeled with all options and accessories indicated and shall be for this specific project.

C. Shop Drawings: Submit complete shop fabrication and installation drawings, including plans, elevations, sections, details and schedules. Show relationship to adjoining materials and construction. Shop Drawings shall be in the form of reproducibles or photocopies, not to exceed 11 inches x 17 inches (A3) in size. Blueline prints are not acceptable.

D. Samples: Submit for Architect's approval two (2) samples of each type of specified finish and color range available.

E. Certifications: As a condition of acceptance, submit certification stating that equipment is complete and ready for intended function.

F. Operations/Maintenance Manuals: Accompanying certification, submit for Architect's review and Owner's use, complete operating and maintenance manuals that describe proper operating procedures, maintenance and replacement schedules, components parts list, and closest factory representative for components and service.

1.6 QUALIFICATIONS
A. Contractor for work in this section shall have an established organization and production facilities including all tools, equipment and special machinery necessary for specializing in the fabrication and installation of the type of equipment specified, with skilled personnel, factory trained workmen and an experienced engineering department. Each shall have the demonstrated knowledge, ability and the proven capability to produce the specified equipment of the required quality and the proven capacity to complete an installation of this size and type within the required time limits.

1.7 COORDINATION
A. Work of this Section requires close coordination with Work of Divisions 22, 23 and 26 and Work specified in other Sections. Sequence all Work to ensure an orderly progress in the project without removal of previously installed Work and so as to prevent damage to finishes and products.

1.8 SUBSTITUTIONS
A. Approved Substitution/Approved Equal: In addition to the items required in Division 1, all substitution requests shall include item-by-item comparison of the proposed substitution to this project specification. A copy of the project specification shall be submitted, with each item and subsection of the project specification marked as “Comply” or “Not Comply.” In any cases where “Not Comply” is indicated, an explanation of the relative advantages of the proposed design shall be provided.

B. Substitution shall not affect dimensions shown on Drawings.
C. The Contractor shall pay for changes to the building design, including engineering design, detailing, utility and service requirements, and construction costs caused by the requested substitution.

D. Substitutions shall have no adverse effect on other trades, the construction schedule, or specified warranty requirements.

E. Maintenance and service parts shall be locally available for the proposed substitution.

F. Regulatory: Specified products, materials, or systems for Project may include engineering or on file standards required by the Regulatory Agency. Contractor’s substitution of products, materials or systems may require additional engineering, testing, reviews, approvals, assurances, or other information for compliance with Regulatory Agency requirements or both. Contractor shall provide all Agency approvals or other additional information required and pay additional costs for required Architect’s services made necessary by the substitution at no increase in Contract Sum or schedule time, and as a part of substitution proposal.

1.9 PRODUCT HANDLING

A. Protection: Use all means necessary to protect work of this section before, during and after installation including installed work and materials of other trades.

B. Replacement: Any damage as a result of this contractors work will be replaced, repaired and restored to original condition to the approval of the Architect at no additional cost or inconvenience to the Owner.

1.10 WARRANTY

A. Refer to the General Conditions and Division 1 "Product Requirements" for warranty requirements. In addition to these requirements, all products will be warranted to be free from defects in materials and workmanship for a minimum period of one year following substantial completion. The manufacturer/dealer/subcontractor shall repair or replace any products (or parts thereof) that are found to be defective. Replacement will include any parts, labor, shipping, and travel expenses involved.

B. Autoclave chambers shall be warranted to be free from defects in materials and workmanship for a minimum period of 15 years following substantial completion.

PART 2 - PRODUCTS

2.1 LABORATORY GLASSWARE WASHER/DRYERS: BASE CABINET HEIGHT

A. Manufacturers/Models: Products, as listed below, which comply with this specification section as judged and approved by the Architect, may be provided by the following manufacturers, listed in alphabetical order:

   a. Model: Flaskscrubber

   a. Model: 815LX
   a. Model: G7883

   a. Model: Lab500SCL

5. Approved equal.

B. Description: Microprocessor-controlled laboratory glassware washer/dryer with purified water rinsing and with at least 9 automatic wash programs, capable of accepting optional inserts such as open baskets and spindles/injectors for open or injection cleaning of laboratory glassware on two rack levels.

C. Size:
   1. Minimum Chamber Dimensions: 20½ inches wide x 18½ inches high x 20 inches deep.
   2. Minimum Chamber Volume: 4.5 cubic feet.
   3. Maximum Overall Dimensions: 24½ inches wide x 34½ inches high x 27½ inches deep.

D. Door Configuration: Bottom-hinged, fold-down door with safety interlock.

E. Product Characteristics:
   1. Construction:
      a. Insulated, fully cabinet-enclosed unit to allow for freestanding or under-counter installation. See Laboratory Furnishing drawings for location.
      b. Chamber and door:
         1). Walls and ceiling, type 304 or 316 stainless steel
         2). Floor and door, type 304 or 316 stainless steel.
      c. Exterior: Type 304 stainless steel.
   2. Control System: Control panel with LCD display to indicate cycle times, temperature, and error messages.
   3. Operation/ Performance:
      a. Dual pump system with separate pumps for circulation and draining.
      b. Rotating upper and lower wash arms.
      c. Circulation pump: rated at a minimum of 92 gpm.
      d. Minimum Heater rating: 2 kW.
      e. Wash water temperature: Unit shall be capable of attaining a wash temperature of 199°F (93°C).
      f. Final rinse temperature: Unit shall be capable of attaining a final purified water rinse temperature of 199°F (93°C).
      g. Easily-removable filter system to catch debris at bottom of the chamber.
      h. Drying system: Unit can use any of the following drying systems:
         1). Gravity-convected drying via an electrical heating element.
         2). Drying via an electrical heating element with an internal chamber circulation fan.
         3). Non-filtered fan-driven drying system.
      i. Detergents: Unit shall be capable of operating with both detergent and neutralizer. Dispensing shall either be manual or automatic.
      j. Noise Level: Unit shall operate at a noise level not exceeding 70 dBA.

F. Utility Requirements:
1. Contractor to coordinate utility requirements with selected manufacturer’s installation guide. The utility requirements below are intended to be able to accommodate any of the specified units.


3. Cold water: Input pressure 29 to 87 psig.

4. DI rinse water: Input pressure 29 to 60 psig.

5. Electric: 208 V, 60 Hz, single-Phase, 12-40 A. Provide washer with cord and plug to match electrical receptacle.

6. Drain: Connect to sink tailpiece, standpipe, or into adjacent floor sink. Refer to drawings for details. Maximum flow rates: 10.5 gpm.

G. Listing:
1. Unit shall carry an ETL mark signifying certification to UL Standard 3101-1/61010-1 or CAN/CSA C22.2 No. 1010.1.

H. Accessories required:
1. Drain water cool-down kit.
2. Provide an initial set of detergent and neutralizer chemicals, sufficient for a minimum of 50 washes, per unit.
3. Glassware accessories:
   a. Lower rack with a minimum of 19 spindles to provide for injection cleaning for narrow-neck glassware.
   b. Utensil basket(s) of approximately 512 cubic inch capacity with lid/cover(s).
   c. Bottle insert for a capacity of a minimum of 18 bottles, and a nominal grid size of 70 mm x 70 mm; type 304 stainless steel.

2.2 LABORATORY STERILIZER (AUTOCLAVE): SMALL

A. Manufacturers: Products, which comply with this specification section as judged and approved by the Architect, may be provided by the following manufacturers. All products specified in this section shall be the provided by a single manufacturer.

6. Approved equal.

B. Description: Small size steam-jacketed sterilizer designed for use in Laboratory and industrial applications.

C. Chamber Size:
1. 20 inches x 20 inches x 38 inches (508 x 508 x 965 mm) nominal.

D. Door/Mounting Configuration:
1. Single door, cabinet enclosed unit.

E. Process Cycle Configuration:
1. Prevacuum: Prevacuum process shall be designed for fast, efficient sterilization of porous, heat- and moisture-stable materials, sterilization of liquids and media in
borosilicate glass containers with vented closures, and decontamination of supplies after laboratory procedures. Prevacuum sterilizer shall be equipped with prevacuum, gravity, liquid, leak test and daily air removal test cycles.

F. Steam Source:
   1. Integral electric carbon steel steam generator supplied with industrial water.

G. Product Characteristics:
   1. Construction:
      a. Shell Assembly: Double wall, jacketed and insulated. Type 316L stainless steel welded sterilizer pressure vessel and type 304L or 316L stainless steel jacket. ASME rated at design operating pressure with allowance to relief valve setpoint - minimum 45 psig (310 kPa). Polished and passivated internal surfaces. Steam supply opening inside chamber to be shielded by a Type 316L stainless steel baffle. Chamber designed for positive sloped drainage with screen drain inlet to prevent debris for entering drain piping.
      b. Door Assembly: Vertical sliding door. Type 316L stainless steel, insulated with jacket. Door suspended by cable/pulley or chain/sprocket supports attached to counterweight or dual-spring assembly. Steam or compressed air activated recessed door gasket seal. Equipped with mechanical safety locking mechanism to prevent door opening when chamber pressure exceeds 2 psi (14 kPa). Provide door safety switch to prevent addition of steam to chamber unless door is closed and locked.
      c. Front Cabinet Panel: Type 304 or 316L stainless steel with No. 4 finish. Hinged or removable for full access to sterilizer piping and control systems.
      d. Side Panels: Sterilizer to be enclosed by Type 304 or 316L stainless steel removable side panels with No. 4 finish. Sterilizer sub-frame to be equipped with a synthetic rubber gasket to ensure tight fit between cabinet panels.
      e. Vacuum System: Liquid-ring vacuum pump to reduce chamber pressure during prevacuum and post-drying phase.
      f. Plumbing: All valves, fittings, and other plumbing components shall be non-proprietary. Custom manifolds or distribution systems shall not be installed. The piping system shall be designed such that all valve types used are from the same manufacturer for ease of maintenance. All utility piping connections shall terminate within the confines of the sterilizer and to be accessible from the front or access side of the unit. Provide ASME approved pressure relief valves rated for pressure vessels.
      g. Electrical: Electrical components such as switches, relays, and wiring systems shall be non-proprietary. Electrical design and installation shall conform to NEC requirements. Provide appropriate enclosure for components to protect against wet and moist environments.
      h. Floor Stand: Sterilizer to be equipped with a leveling height-adjustable floor stand manufactured of extruded aluminum structural members or welded stainless steel, or welded carbon steel with corrosion protective finish.

2. Control System:
   a. General: The sterilizer control system shall monitor, control, display, and record all process parameters. The control system shall include a PLC controller, touch-screen operator interface control panel, printer, audible alert, and emergency manual off (EMO) safety switch.
   b. Programmable Logic Controller (PLC) Controller: Non-proprietary controller to display, monitor, and control all sterilizer operations and functions. Allen-Bradley® MicroLogix™ control system or equal.
c. Touch Screen Operator Interface Control Panel: Color active matrix (TFT) touch sensitive color interface screen. Allen-Bradley® PanelViewPlus™ or equal. Provide one screen on each side of pass-through units.

d. Printer: Alphanumeric ink-on-paper dot-matrix impact or permanent thermal paper printer with take-up spool.

e. Programming: All programming to be stored in non-volatile memory to retain programming during a power outage. Provide help menus/screens for programming and troubleshooting alarm conditions. Provide security features to prevent inadvertent or unauthorized process changes. Provide user programmable time-of-day utility startup/shutdown schedules for energy savings.

f. RS-232 or equivalent communication protocol for downloading cycle information.

g. USB or compact flash memory card slot for memory backup/restore and downloading cycle information.

H. Utilities:

1. Contractor to coordinate utility requirements with selected manufacturer’s installation guide. The utility requirements below are intended to accommodate any of the specified units.

2. Electric Steam Generator Unit:
   a. Drain: 1½ inch (38 mm) ODT.
   b. Generator drain: ½ inch (12.7 mm) ODT.
   c. Electrical Controls: 120V, 60 Hz.
   d. Electric Steam Generator: 480 V, 60 Hz, 3-phase.
   e. Electric Vacuum Pump: 480 V, 60 Hz, 3-phase
   f. Sterilizer feed water: Industrial cold water, 1 inch (25.4 mm) NPT, 30-50 psig (207-345 kPa) dynamic.
   g. Steam generator feed water: Industrial softened hot water, ½ inch (12.7 mm) NPT, 20-50 psig (138-345 kPa) dynamic.

I. Standards: Units shall conform to the applicable requirements of the following:

1. Underwriters Laboratories (UL).
3. NEC.
4. ASME Code, Section VIII, Division 1 for unfired pressure vessels.
5. ASME Code, Section I, Part PMB for power boilers.

J. Options Required:

1. Drain discharge cool down to limit discharge temperature into waste systems below 140°F.
2. Minimum 12-cycle capacity.
3. Seismic tie-down kit required to conform to local building codes.
4. Auto flush cycle for carbon steel steam generator with programmable timer/controls.
5. Power operated door.
6. Boiler Control and Safety Device (CSD-1) for secondary low water cut-off as required by local jurisdiction.
7. Air compressor if required. Provide wall mounted powder coated steel or stainless steel shelf to support air compressor as well as anchorage and vibration isolation. Coordinate with Division 26 to provide electrical receptacle on dedicated circuit adjacent to compressor. Coordinate with Division 23 to provide all necessary piping per manufacturer’s recommendations and local code requirements.

K. Accessories Required:

1. Rack and shelves.
PART 3 - EXECUTION

3.1 SITE CONDITIONS

A. Inspection: Prior to installation of laboratory equipment, carefully inspect the installed work specified in other Sections and verify that all such work is complete to the point where this installation may properly commence.

B. Discrepancies: In the event of discrepancy, immediately notify the Architect.

3.2 EXAMINATION

A. Examine surfaces designated to receive work for conditions that would adversely affect the finished work. Repair or replace surfaces not meeting tolerances or quality requirements governing substrate construction prior to start of work.

B. Verify that surfaces, prepared openings, or support structures are ready to receive work.

C. Verify field measurements and opening dimensions are as instructed by manufacturer.

D. Inspect and verify that the required utilities are available, in proper locations, prior to equipment installation.

3.3 WORK REQUIRED OF OTHER SECTIONS PRIOR TO INSTALLATION

A. Install shutoff valves on service lines.

B. Install fused disconnect switches (with lockout in OFF position) in electric supply lines near the equipment.

C. Provide building service lines supplying specified pressures and flow rates.

D. Provide recommended feed water quality for carbon steel steam generators as follows: Total hardness as CaCO3-max 85 mg/l; Total alkalinity as CaCO3-max 180 mg/l; Total dissolved solids-max 150 mg/l; Total Silica-max 2.5 mg/l; pH-7.5.

E. Provide illumination of service area, with provision of convenience outlet for maintenance.

3.4 INSTALLATION

A. General:
   1. Install all equipment per manufacturer's recommendations and reviewed submittals.
   2. Properly align and position all equipment.

B. Connection to Building Systems: See Laboratory Plumbing and Electrical drawings and Divisions 22 & 23 and 26 for final connections.
3.5 START UP AND TESTING

A. Test, clean, and adjust equipment and apparatus installed to ensure performance meets specified requirements.

B. Operate each unit and test full range of cycles over a continuous period. Record test data.

C. Adjust and re-test any units not meeting requirements.

3.6 DEMONSTRATION AND INSTRUCTIONS

A. Engage services of factory-qualified instructor to instruct and train Owner's operating and maintenance personnel in operation, service, and maintenance of equipment.

B. Test equipment prior to demonstration. Ensure equipment, including specified accessories, is operational.

C. Provide demonstration of equipment operation and instruction of Owner's personnel.

D. Demonstrate operating capability of equipment and systems. Include control and safety features, and service and maintenance procedures.

3.7 CLEANING AND PROTECTION

A. All equipment shall be protected before, during and after installation. Damage to material due to improper protection shall be cause for rejection.

B. Packaging and debris and other waste resulting from installation of equipment will be removed.

C. Repair or remove and replace defective Work as directed by the Architect upon completion of installation.

D. Clean finished equipment, touch up as required and remove and refinish damaged or soiled areas.

E. Prior to final acceptance by the customer, equipment that has become damaged will be repaired or replaced according to the terms of the warranty and any external soiled surfaces will be cleaned.

END OF SECTION
SECTION 120413 - COMMON SUBMITTAL REQUIREMENTS FOR FURNISHINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER’S AND GENERAL CONTRACTOR’S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect’s staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
   1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be ‘broken out’ for special handling. Arrange submittals accordingly.

C. Submittal Numbering
   1. Number submittals as described below to assist tracking.
   2. Number each submittal in the format nnnnnn-nn.
      a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
      b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
      c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
      d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
      e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 122413 - ROLLER WINDOW SHADES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Manually operated roller shades.
   2. Electrically operated, roller shades. Include local and remote group and master motor control systems for shade operation with addressable, encoded, electronic drive units (EDU), remote control, and network interface.

B. Related Requirements:
   1. Division 06 Section for wood blocking and grounds for mounting roller shades and accessories.
   2. Division 26 and 27 - Electrical: Electric service for motors, motor controls, internal communication, low voltage wiring and data transfer, and connection to Internet.

1.3 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 120413.

B. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, features, finishes, and operating instructions for roller shades.

C. Sustainable Design Submittals required by Section 01813 applicable to this Section.

D. Shop Drawings: Show fabrication and installation details for roller shades, including shadeband materials, their orientation to rollers, and their seam and batten locations.

E. Samples for Verification: For each type of roller shade.
   1. Shadeband Material: Not less than 10 inches square. Mark interior face of material if applicable.

F. Window Treatment Schedule: For roller shades.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For roller shades to include in maintenance manuals.
1.5 QUALITY ASSURANCE

A. Installer Qualifications: Installer trained and certified by roller shade manufacturer with a minimum of ten years experience installing products comparable to those specified in this section.

B. Fire-Test-Response Characteristics: Passes NFPA 701 small and large-scale vertical burn. Materials tested shall be identical to products proposed for use.

C. Electrical Components: NFPA Article 100 listed and labeled by either UL or ETL or other testing agency acceptable to authorities having jurisdiction, marked for intended use, and tested as a system. Individual testing of components will not be acceptable in lieu of system testing.

D. ShadeCloth Anti-Microbial Characteristics: 'No Growth' per ASTM G 21

E. Provide the following upon request:
   1. Qualification Data: For Installer.
   2. Product Certificates: For each type of shadeband material.
   3. Product Test Reports: For each type of shadeband material, for tests performed by manufacturer and witnessed by a qualified testing agency or by a qualified testing agency.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver roller shades in factory packages, marked with manufacturer, product name, and location of installation using same designations indicated on Drawings.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Do not install roller shades until construction and finish work in spaces, including painting, is complete and dry and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

B. Field Measurements: Where roller shades are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Allow clearances for operating hardware of operable glazed units through entire operating range. Notify Architect of installation conditions that vary from Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain roller shades and electronic controllers from single source from single manufacturer including shades, hardware, shade fabric, motors, network interface devices, and related controllers furnished and installed as a complete two-way communicating system and assembly.

B. Basis-of-Design Product: Subject to compliance with requirements, provide products by MechoShade Systems, Inc., or comparable product by one of the following:
1. Draper Inc.
3. Lutron Electronics Co., Inc.

2.2 MANUALLY OPERATED SHADES WITH SINGLE ROLLERS – TYPE 1

A. Chain-and-Clutch Operating Mechanisms: With continuous-loop bead chain and clutch that stops shade movement when bead chain is released; permanently adjusted and lubricated.
      a. Limit Stops: Provide upper and lower ball stops.
      b. Chain-Retainer Type: Clip, jamb mount.
   2. Spring Lift-Assist Mechanisms: Manufacturer's standard for balancing roller shade weight and for lifting heavy roller shades.
      a. Provide for shadebands that weigh more than 10 lb or for shades as recommended by manufacturer, whichever criterion is more stringent.

B. Rollers: Corrosion-resistant steel or extruded-aluminum tubes of diameters and wall thicknesses required to accommodate operating mechanisms and weights and widths of shadebands indicated without deflection. Provide with permanently lubricated drive-end assemblies and idle-end assemblies designed to facilitate removal of shadebands for service.
   1. Shadeband-to-Roller Attachment: Manufacturer's standard method.

C. Mounting Hardware: Brackets or endcaps, corrosion resistant and compatible with roller assembly, operating mechanism, installation accessories, and mounting location and conditions indicated.

D. Shadebands:
   2. Shadeband Bottom (Hem) Bar: Steel or extruded aluminum.
      a. Type: Enclosed in sealed pocket of shadeband material.

E. Installation Accessories:
   1. Recessed Shade Pocket: Rectangular, extruded-aluminum enclosure designed for recessed ceiling installation; with front, top, and back formed as one piece, end plates, and removable bottom closure panel.
      a. Provide pocket with lip at lower edge to support acoustical ceiling panel.

2.3 MANUALLY OPERATED SHADES WITH DOUBLE ROLLERS – TYPE 2

A. Chain-and-Clutch Operating Mechanisms: With continuous-loop bead chain and clutch that stops shade movement when bead chain is released; permanently adjusted and lubricated.
      a. Limit Stops: Provide upper and lower ball stops.
      b. Chain-Retainer Type: Clip, jamb mount.
   2. Spring Lift-Assist Mechanisms: Manufacturer's standard for balancing roller shade weight and for lifting heavy roller shades.
a. Provide for shadebands that weigh more than 10 lb or for shades as recommended by manufacturer, whichever criterion is more stringent.

B. Rollers: Corrosion-resistant steel or extruded-aluminum tubes of diameters and wall thicknesses required to accommodate operating mechanisms and weights and widths of shadebands indicated without deflection. Provide with permanently lubricated drive-end assemblies and idle-end assemblies designed to facilitate removal of shadebands for service.
   1. Double-Roller Mounting Configuration: Offset, outside roller over and inside roller under.
   2. Shadeband-to-Roller Attachment: Manufacturer's standard method.

C. Mounting Hardware: Brackets or endcaps, corrosion resistant and compatible with roller mounting configuration, roller assemblies, operating mechanisms, installation accessories, and installation locations and conditions indicated.

D. Roller-Coupling Assemblies: Coordinated with operating mechanism and designed to join up to three inline rollers into a multiband shade that is operated by one roller drive-end assembly.

E. Inside Shadebands:
   2. Shadeband Bottom (Hem) Bar: Steel or extruded aluminum.
      a. Type: Enclosed in sealed pocket of shadeband material.

F. Outside Shadebands:
   2. Shadeband Bottom (Hem) Bar: Steel or extruded aluminum.
      a. Type: Enclosed in sealed pocket of shadeband material.

G. Installation Accessories:
   1. Recessed Shade Pocket: Rectangular, extruded-aluminum enclosure designed for recessed ceiling installation; with front, top, and back formed as one piece, end plates, and removable bottom closure panel.
      a. Provide pocket with lip at lower edge to support acoustical ceiling panel.
   2. Side Channels: With light seals and designed to eliminate light gaps at sides of shades as shades are drawn down. Provide side channels with shadeband guides or other means of aligning shadebands with channels at tops.
   3. Bottom (Sill) Channel or Angle: With light seals and designed to eliminate light gaps at bottoms of shades when shades are closed.
   4. Installation Accessories Color and Finish: As selected from manufacturer's full range.

2.4 MOTOR-OPERATED, SINGLE-ROLLER SHADES – TYPE 3

A. Motorized Operating System: Provide factory-assembled, shade-operator system of size and capacity and with features, characteristics, and accessories suitable for conditions indicated, complete with electric motor and factory-prewired motor controls, power disconnect switch, enclosures protecting controls and operating parts, and accessories required for reliable operation without malfunction. Include wiring from motor controls to motors. Coordinate operator wiring requirements and electrical characteristics with building electrical system.
   1. Electrical Components: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Electric Motor: Manufacturer's standard tubular, enclosed in roller.
b. Maximum Total Shade Width: As required to operate roller shades indicated.
c. Maximum Shade Drop: As required to operate roller shades indicated.
d. Maximum Weight Capacity: As required to operate roller shades indicated.

3. Remote Control: Electric controls with NEMA ICS 6, Type 1 enclosure for recessed or flush mounting. Provide the following for remote-control activation of shades:
   a. Keyed Control Station: Keyed, momentary-contact, three-position, switch-operated control station with open, close, and off functions. Provide two keys per station.
   b. Color: As selected by Architect from manufacturer's full range.

4. Crank-Operator Override: Crank and gearbox operate shades in event of power outage or motor failure.

5. Limit Switches: Adjustable switches interlocked with motor controls and set to stop shades automatically at fully raised and fully lowered positions.

6. Operating Features:
   a. Individual and group switching with wireless intelligent network control system.
   b. Integrated local switch control; single faceplate for multiple switch cutouts.
   c. Capable of accepting future input from building automation control system.
   d. Override switch.

B. Rollers: Corrosion-resistant steel or extruded-aluminum tubes of diameters and wall thicknesses required to accommodate operating mechanisms and weights and widths of shadebands indicated without deflection. Provide with permanently lubricated drive-end assemblies and idle-end assemblies designed to facilitate removal of shadebands for service.
   1. Roller Drive-End Location: Right side of interior face of shade.
   2. Direction of Shadeband Roll: Regular, from back (exterior face) of roller.

C. Mounting Hardware: Brackets or endcaps, corrosion resistant and compatible with roller assembly, operating mechanism, installation accessories, and mounting location and conditions indicated.

D. Roller-Coupling Assemblies: Coordinated with operating mechanism and designed to join up to three inline rollers that are operated by one roller drive-end assembly.

E. Shadebands:
   2. Shadeband Bottom (Hem) Bar: Steel or extruded aluminum.
      a. Type: Enclosed in sealed pocket of shadeband material.
      b. Color and Finish: As selected by Architect from manufacturer's full range.

F. Installation Accessories:
   1. Recessed Shade Pocket: Rectangular, extruded-aluminum enclosure designed for recessed ceiling installation; with front, top, and back formed as one piece, end plates, and removable bottom closure panel.
      a. Height: Manufacturer's standard height required to enclose roller and shadeband assembly when shade is fully open, but not less than 4 inches.
      b. Provide pocket with lip at lower edge to support acoustical ceiling panel.
   2. Closure Panel and Wall Clip: Removable aluminum panel designed for installation at bottom of site-constructed ceiling recess or pocket and for snap-in attachment to wall clip without fasteners.
      a. Closure-Panel Width: 2 inches.
   3. Installation Accessories Color and Finish: As selected from manufacturer's full range.
2.5 SHADEBAND MATERIALS

A. Shadeband Material Flame-Resistance Rating: Comply with NFPA 701. Testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

B. Light-Filtering Fabric: Woven fabric, stain and fade resistant.
   1. Source: Roller shade manufacturer.
   2. Openness Factor: 1 percent, fabric type as selected by Architect.
   3. Color: As indicated on Drawings.

   1. Source: Roller shade manufacturer.
   3. Color: As indicated on Drawings.

2.6 INTELLIGENT ENCODED ELECTRONIC DRIVE SYSTEM (120VAC)

A. Electronic Drive Unit (EDU):
   1. Intelligent Encoded EDU, and Control System: Quiet, tubular, asynchronous (non-synchronous) EDU's, with built-in ac motor and reversible capacitor operating at 120VAC/60Hz, (230VAC/50Hz) single phase, temperature Class B, thermally-protected, totally enclosed, maintenance-free and powered by a line voltage power supply connection equipped with locking disconnect plug assembly furnished with each EDU.
   2. EDU shall be concealed inside shade roller tube.
   3. Provide EDU with the ability to upgrade firmware inside the motor from anywhere on the network without touching the motor.

B. EDU System: (software, two-way communication):
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following or comparable by listed manufacturer:
      a. MechoSystems; WhisperShade IQ2 System.
   2. EDU and control systems not in complete compliance with these performance criteria shall not be accepted as equal systems. EDU shall support two methods of control:
      a. Local Isolated Dry Contact Control Inputs: EDU shall be equipped with dry contact inputs to support economical motor control as well as integration to third party systems without adding any interface modules. The dry contact inputs shall support moving the EDU/shade to the upper and lower limits as well as to local switch preset positions. They shall also support configuring the EDU under protected sequences so that a typical user would not change the EDU's setup. At a minimum the configuration should include setting limits, setting custom presets and configuring key modes of operation without requiring a PC or other similar microprocessor-driven tool.
      b. Network Control: EDU shall be equipped with a bi-directional network communication capability in order to support commanding the operation of large groups of shades over a common backbone. The network communication card shall be embedded into the tubular EDU assembly. Upper and lower stopping points (operating limits) of shade bands shall be programmed into EDU's using either a hand held removable program module / configurator or a local switch.

C. Alignment Positions: Each EDU shall support multiple repeatable and precisely aligned shade positions (including limits and presets).
D. Local Switch Presets: A minimum of 3 customizable preset positions shall be accessible over the local dry contact control inputs and over the network connection.

E. Network Presets: Customizable preset positions (including local switch presets) shall be accessible via network commands.

F. Network Control: Capable of two-way digital communication with the EDU's over a common backbone.

G. Low Voltage Communication Network Implementation.

H. Network Capacity: capable up to 4000 feet, with 250 nodes.

I. Uniform or Normal Modes of Operation: Uniform mode shall allow for shades to only move to defined intermediate stop positions to maintain maximum uniformity and organization. Normal Mode shall allow for shades to move to both intermediate stop positions, plus any position desired between the upper and lower limits as set by the installer.

2.7 WIRELESS CONTROLLERS

A. Wireless Controllers (MWC):
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following or comparable by listed manufacturer:
      a. MechoSystems; EnOcean to network interface gateway, router and controller.

2.8 WALL SWITCHES

A. Wired Wall Switches: Shades shall be operated by 2, 4, 5, 7, or 10 button low voltage standard switches. Standard switch shall be wired to a network interface and be programmed to transmit an address for the local switch. An address that is transmitted by either a switch or central controller shall be responded to by those EDU's with the same address in their control table. Standard switch may control an individual, sub-group or group of EDU's in accordance with the address in each EDU.

B. Wireless Wall Switches: Shades shall be operated by 2 button wireless standard switches in conjunction with MWC will be programmed to wireless transmit via 902 MHz RF an address for the local switch. An address that is transmitted by either a switch or central controller shall be responded to by those EDU's with the same address in their control table. Standard switch may control an individual, sub-group or group of EDU's in accordance with the address in each EDU.

2.9 NETWORK INTERFACE

A. Network Interface:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide the following or comparable by listed manufacturer:
      a. MechoSystems; MechoNet.
2.10 ROLLER SHADE FABRICATION

A. Product Safety Standard: Fabricate roller shades to comply with WCMA A 100.1, including requirements for flexible, chain-loop devices; lead content of components; and warning labels.

B. Unit Sizes: Fabricate units in sizes to fill window and other openings as follows, measured at 74 deg F:
   1. Between (Inside) Jamb Installation: Width equal to jamb-to-jamb dimension of opening in which shade is installed less 1/4 inch per side or 1/2-inch total, plus or minus 1/8 inch. Length equal to head-to-sill or -floor dimension of opening in which shade is installed less 1/4 inch, plus or minus 1/8 inch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, operational clearances, locations of connections to building electrical system, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 ROLLER SHADE INSTALLATION

A. Install roller shades level, plumb, and aligned with adjacent units according to manufacturer's written instructions.
   1. Opaque Shadebands: Located so shadeband is not closer than 2 inches to interior face of glass. Allow clearances for window operation hardware.

B. Roller Shade Locations: As indicated on Drawings.

3.3 INSTALLATION OF CONTROL SYSTEMS

A. Install control systems in accordance with manufacturer's recommendations and approved submittals.

B. Participate and cooperate with the electrical contractor, shade manufacturer and the commissioning agent to verify and certify the installation is in full conformance with the specifications and is fully operational. This work to occur during the commissioning stage and is in addition to preliminary acceptance required for each floor.

3.4 ADJUSTING

A. Adjust and balance roller shades to operate smoothly, easily, safely, and free from binding or malfunction throughout entire operational range.
3.5 CLEANING AND PROTECTION
   A. Clean roller shade surfaces, after installation, according to manufacturer's written instructions.
   B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that roller shades are without damage or deterioration at time of Substantial Completion.
   C. Replace damaged roller shades that cannot be repaired, in a manner approved by Architect, before time of Substantial Completion.

3.6 DEMONSTRATION
   A. Engage a factory-authorized service representative to train District's maintenance personnel to adjust, operate, and maintain motor-operated roller shades.

END OF SECTION
SECTION 123661.16 - SOLID SURFACING COUNTERTOPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Solid surface material countertops.
2. Solid surface material backsplashes.
3. Solid surface material end splashes.
4. Solid surface material apron fronts.
5. Solid surface material sinks.

B. Related Requirements:
1. Section 055000 "Metal Fabrications" for miscellaneous steel brackets and supports for wall-mounted countertops and vanities.
2. Section 061000 "Rough Carpentry" for support framing, grounds, and concealed blocking.
3. Division 22 section for "Plumbing Fixtures" for non-integral sinks and plumbing fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For countertop materials.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: For countertops. Show materials, finishes, edge and backsplash profiles, methods of joining, and cutouts for plumbing fixtures.
   1. Show locations and details of joints.
   2. Show attachment to subtop and subtop attachment to adjoining structure.

D. Samples for Verification: For the following products:
   1. Countertop material, 6 inches square.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For solid surface material countertops to include in maintenance manuals. Include Product Data for care products used or recommended by Installer and names, addresses, and telephone numbers of local sources for products.
1.5 QUALITY ASSURANCE

A. Fabricator Qualifications: Shop that employs skilled workers who custom-fabricate countertops similar to that required for this Project, and whose products have a record of successful in-service performance.

B. Installer Qualifications: Fabricator of countertops.

C. Provide the following upon request:
   1. Qualification Data: For fabricator.

D. Mockups: Build in-place mockups to demonstrate aesthetic effects and to set quality standards for fabrication and execution.
   1. Build mockup of typical countertop as shown on Drawings; not less than 60 inch long counter with backsplash.
   2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 FIELD CONDITIONS

A. Field Measurements: Verify dimensions of countertops by field measurements after base cabinets are installed but before countertop fabrication is complete.

1.7 COORDINATION

A. Coordinate locations of utilities that will penetrate countertops or backsplashes.

PART 2 - PRODUCTS

2.1 SOLID SURFACE COUNTERTOP MATERIALS

A. Solid Surface Material: Homogeneous-filled plastic resin complying with ICPA SS-1.
   1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporates into the Work include, but are not limited to, the following]:
   2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Avonite Surfaces.
      c. Formica Corporation.
      d. LG Chemical, Ltd.
      e. Wilsonart International Holdings, Inc.
   3. Type: Provide Standard type unless Special Purpose type is indicated.
   5. Colors and Patterns: As indicated by manufacturer’s designations.
B. Composite Wood Products: Products shall be made using ultra-low-emitting formaldehyde resins as defined in the California Air Resources Board's "Airborne Toxic Control Measure to Reduce Formaldehyde Emissions from Composite Wood Products" or shall be made with no added formaldehyde.

C. Plywood: Exterior softwood plywood complying with DOC PS1, Grade C-C Plugged, touch sanded, vented.

D. Marine-grade Plywood: APA FIR HDO MARINE 3/4" according to Voluntary Product Standard PS 1-95 "Construction and Industrial Plywood" adhered with exterior glue, vented. Use at countertops with sinks.

2.2 COUNTERTOP FABRICATION

A. Fabricate countertops according to solid surface material manufacturer's written instructions and to the AWI/AWMAC/WI's "Architectural Woodwork Standards."
   1. Grade: Custom.

B. Configuration:
   1. Front: Straight, slightly eased at top.
   2. Backsplash: Straight, slightly eased at corner.

C. Countertops: 3/4-inch thick, solid surface material with front edge built up with same material.

D. Backsplashes: 1/2-inch thick, solid surface material.

E. Fabricate tops with shop-applied edges and backsplashes unless otherwise indicated. Comply with solid surface material manufacturer's written instructions for adhesives, sealers, fabrication, and finishing.
   1. Fabricate with loose backsplashes for field assembly.
   2. Install integral sink bowls in countertops in the shop.

F. Joints: Fabricate countertops without joints.

G. Subtop Venting: Provide drilled holes according to countertop material manufacturer's instructions, or provide ladder-framed plywood subtop to equalize temperature and humidity on both sides of countertop.

H. Cutouts and Holes:
   1. Undercounter Plumbing Fixtures: Make cutouts for fixtures in shop using template or pattern furnished by fixture manufacturer. Form cutouts to smooth, even curves.
      a. Provide vertical edges, slightly eased at juncture of cutout edges with top and bottom surfaces of countertop and projecting 3/16 inch into fixture opening.
      b. Provide vertical edges, rounded to 3/8-inch radius at juncture of cutout edges with top surface of countertop, slightly eased at bottom, and projecting 3/16 inch into fixture opening.
      c. Provide 3/4-inch full bullnose edges projecting 3/8 inch into fixture opening.
3. Fittings: Drill countertops in shop for plumbing fittings, undercounter soap dispensers, and similar items.

2.3 INSTALLATION MATERIALS

A. Adhesive: Product recommended by solid surface material manufacturer.
   1. Adhesives shall have a VOC content of [70] \(<\text{Insert value}\) g/L or less.
   2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Sealant for Countertops: Comply with applicable requirements in Section 079200 "Joint Sealants."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates to receive solid surface material countertops and conditions under which countertops will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of countertops.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install countertops level to a tolerance of 1/8 inch in 8 feet, 1/4 inch maximum. Do not exceed 1/64-inch difference between planes of adjacent units.

B. Wall-mounted subtops: Fasten subtops to wood nailers attached to wall-supported steel brackets. Predrill holes for screws as recommended by manufacturer. Shim as needed to align subtops in a level plane.

C. Base-mounted subtops: Fasten subtops to cabinets by screwing through subtops into cornerblocks of base cabinets. Predrill holes for screws as recommended by manufacturer. Shim as needed to align subtops in a level plane.

D. Install countertops over subtops with full spread of water-cleanable epoxy adhesive according to solid surface material manufacturer's written instructions.

E. Align adjacent surfaces and, using adhesive in color to match countertop, form seams to comply with manufacturer's written instructions. Carefully dress joints smooth, remove surface scratches, and clean entire surface.

F. Bond joints with adhesive and draw tight as countertops are set. Mask areas of countertops adjacent to joints to prevent adhesive smears.
   1. Install metal splines in kerfs in countertop edges at joints. Fill kerfs with adhesive before inserting splines and remove excess immediately after adjoining units are drawn into position.
2. Clamp units to temporary bracing, supports, or each other to ensure that countertops are properly aligned and joints are of specified width.

G. Install backsplashes and end splashes by adhering to wall and countertops with adhesive. Mask areas of countertops and splashes adjacent to joints to prevent adhesive smears.

H. Install aprons to backing and countertops with adhesive. Mask areas of countertops and splashes adjacent to joints to prevent adhesive smears. Fasten by screwing through backing. Predrill holes for screws as recommended by manufacturer.

I. Complete cutouts not finished in shop. Mask areas of countertops adjacent to cutouts to prevent damage while cutting. Make cutouts to accurately fit items to be installed, and at right angles to finished surfaces unless beveling is required for clearance. Ease edges slightly to prevent snipping.

1. Seal edges of cutouts in particleboard subtops by saturating with varnish.

J. Apply sealant to gaps at walls; comply with Section 079200 "Joint Sealants."

END OF SECTION
SECTION 124813 - ENTRANCE FLOOR MATS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary
      Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section Includes:
      1. Rubber-backed woven carpet entry mats.

1.3 ACTION SUBMITTALS
   A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance
      Form may be submitted in lieu of required Product Data submittal. Ensure compliance with
      requirements included in Section 120413.
   B. Product Data: For each type of product.
      1. Include construction details, material descriptions, dimensions of individual components
         and profiles, and finishes for floor mats and frames.
   C. Sustainable Design Submittals required by Section 01813 applicable to this Section.
   D. Samples: For the following products, in manufacturer's standard sizes:
      1. Floor Mat: Assembled sections of floor mat.

1.4 CLOSEOUT SUBMITTALS
   A. Maintenance Data: For floor mats and frames to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS
   A. Furnish extra materials that match products installed and that are packaged with protective
      covering for storage and identified with labels describing contents.
      1. Entrance Mats: Full-size tile roll equal to 2 percent of amount installed, but no fewer than
         60 square feet.
PART 2 - PRODUCTS

2.1 ENTRANCE FLOOR MATS AND FRAMES, GENERAL

A. Accessibility Standard: Comply with applicable provisions in the DOJ's "2010 ADA Standards for Accessible Design" and CBC Title 24 Chapter 11B.

2.2 RUBBER-BACKED ENTRY MATS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Interface.
   2. Amaro Products.

B. Characteristics:
   1. Pile Height: 3/8 inch.
   2. Total Thickness: 1/2 inch
   3. Pile Weight: 52 oz/sq. yd.
   4. Surface Flammability: ASTM D 2859; Pass
   5. Static Electrical Propensity: Less than 2 kV

2.3 FABRICATION

A. Floor Mats: Shop fabricate units to greatest extent possible in sizes indicated. Unless otherwise indicated, provide single unit for each mat installation; do not exceed manufacturer's recommended maximum sizes for units that are removed for maintenance and cleaning. Where joints in mats are necessary, space symmetrically and away from normal traffic lanes. If necessary, form seams as instructed by manufacturer.

B. Recessed Mats: As indicated, for permanent recessed installation, coordinate depth with concrete placement.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and floor conditions for compliance with requirements for location, sizes, [minimum recess depth, ]and other conditions affecting installation of floor mats and frames.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install recessed mats to comply with manufacturer's written instructions so that tops of mats will be flush with adjoining finished flooring. Set mats with tops at height recommended by manufacturer for most effective cleaning action; coordinate tops of mat surfaces with bottoms of doors that swing across mats to provide clearance between door and mat.
1. Install necessary shims, spacers, and anchorages for proper location, and secure attachment of frames.
2. Delay setting mats until construction traffic has ended.

3.3 PROTECTION

A. After completing frame installation and concrete work, provide temporary filler of plywood or fiberboard in recesses and cover frames with plywood protective flooring. Maintain protection until construction traffic has ended and Project is near Substantial Completion.

END OF SECTION
SECTION 126100 - FIXED AUDIENCE SEATING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes fixed audience sequence seating with the following:
   1. Beam mounting.
   2. Molded-plastic chairs with foldaway tablet arms.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of components, and finishes for fixed audience seating.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Seating Layout: Show seating layout, aisle widths, aisle-end alignment or stepping, row-lettering and chair-numbering scheme, chair widths, and chair spacing in each row.
   2. Accessories: Show locations and features of accessories, including left- and right-hand tablet arms, and accessibility provisions.

D. Samples for Initial Selection: For each type of exposed color, finish, texture, and pattern indicated.
   1. Include Samples of accessories involving color and finish selection.

E. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below:
   1. Chair Unit: Full-size unit of each type and combination of finishes.
   2. Accessible tablet arm surface with embedded logo.
   3. Molded Plastic: Manufacturer’s standard-size unit, not less than 3 inches square.
   4. Plastic Laminate: Manufacturer’s standard-size unit, not less than 3 inches square.
   5. Baked-on Coating Finishes: Manufacturer’s standard-size unit, not less than 3 inches square.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fixed audience seating to include in operation and maintenance manuals.
1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials from the same production run that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Chair Seats and Backs: 2 percent of quantity installed for each type and size of chair seat and back.
2. Tablet Arms: 5 percent of quantity installed for each type and size of tablet arm; left- and right-hand mounted.
3. Chair Back Articulation Hinges: 5 percent of quantity installed with replacement bellows.

1.6 QUALITY ASSURANCE

A. Provide the following upon request:

1. Product Certificates: For each type of fixed audience seating.
2. Field quality-control reports.

B. Mockups: Build mockups to verify selections made under Sample submittals, demonstrate aesthetic effects, and set quality standards for fabrication and installation.

1. Build mockups of one row with minimum two typical seats in width, beam mounted, with mounting pedestals and tablet arms, including finishes and accessories:
2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of fixed audience seating that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures including standards, beams, and pedestals.
   b. Faulty operation of self-rising seat mechanism.
   c. Wear and deterioration of fabric and stitching beyond normal use.
   d. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.

2. Warranty Periods: As follows, from date of Substantial Completion.
   a. Structural: Five years.
   b. Operating Mechanisms: Three years.
   c. Plastic and Paint Components: Two years.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Source Limitations: Obtain each type of seating required, including accessories and mounting components, from single source from single manufacturer.
2.2 PERFORMANCE REQUIREMENTS

A. Strength and Durability Performance: Chairs and components shall pass testing according to BIFMA X5.4.

2.3 FIXED AUDIENCE SEATING

A. Fixed Audience Seating: Assembly-space seating in permanent arrangement as shown on Drawings.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Dorsal Series G2 Tablet fixed seating as manufactured by KI, Inc., or comparable product by one of the following:
   a. American Seating Company.
   b. Clarin Seating.
   c. Irwin Seating Company.

B. Chair Mounting Standards: Floor attached of the following material:

1. Steel: Stamped steel spiders, secured to the beam yoke below

C. Chair Mounting Beam: Seamless steel horizontal tubular beam mounted on floor -attached steel support pedestal columns spaced according to Drawings.

D. Beam Mounting Pedestal Column: Steel pedestal capped with stamped steel yoke cover to support beam, manufacturer's standard, with floor mounted base plate.

E. Plastic Chairs: Two-piece injection-molded thermoplastic seat and backrest with textured seat and backrest surface on front only. Seat and backrests joined by maintenance-free steel hinge with integral spring mechanism which allows the upper back to articulate with pressure. The hinge shall be covered with high-strength plastic bellows. Four molded-in sills on underside of seat attach to pedestal mounted steel spider.

F. Chair Width: Single-width chair in each row, with minimum chair width as indicated from center to center of armrests.

G. Back Pitch: Fixed.

1. Chair Back Hinges: Self-lubricating type with noiseless mechanism that allows articulation of back rest and covered with plastic bellows with automatic return to vertical position when chair is unoccupied.

H. Tablet Arms: Manufacturer's standard-size, foldaway tablet arm with plastic-laminate writing surface and backer sheet on plywood core, clear lacquered edges.

1. Mounting: Right-hand mounted, except left-hand at aisle seats as indicated.
2. Pivot Mechanism: Two pivot cams, 0 degrees (use position) to 175 degrees (stored position).

I. Accessible Seating:

1. Provide pedestal mounted foldaway tablet arm in accessible locations without chairs.
2. Identify these seats with a sign or marker.

J. Accessibility-Logo Plates: Manufacturer's standard.

1. Material: Aluminum or Stainless steel with black embossed characters.
2. Location: Recessed flush in top of tablet arm surface.
3. Attachment: Adhesive.

2.4 MATERIALS AND FINISHES

1. Composite Wood Products: Made with binder containing no urea formaldehyde.
   Concealed Plywood: HPVA HP-1 hardwood plywood or DOC PS 1 softwood plywood as standard with manufacturer.

B. Plastic Laminate: NEMA LD 3, Grade VGS for vertical surfaces and Grade HGS for horizontal surfaces.
   1. Color and Pattern: As selected by Architect from manufacturer's full range.

C. Molded Plastic: High-density polypropylene, injection molded, with surface that is mar and dent resistant.
   1. Provide with UV inhibitors to retard fading.
   2. Color and Texture: As selected by Architect from manufacturer's full range.

D. Metal Finish: Finish exposed metal parts with manufacturer's standard minimum 1.5-mil-thick, epoxy baked-on powder coating.
   1. Color: As selected by Architect from manufacturer's full range.

2.5 FABRICATION

A. Floor Attachments: Fabricate to conform to floor slope so that standards and pedestals are plumb and chairs are maintained at same angular relationship to vertical throughout Project.

B. Single-Wall, Molded-Plastic Chairs: Contoured plastic shell with smoothly rolled edges and reinforcing ribs on underside of shell. Fabricate for attachment of chair to support with self-threading, corrosion-resistant screws.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine floors, risers, and other adjacent work and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install seating in locations indicated and fasten securely to substrates according to manufacturer's written installation instructions.
   1. Install fixed audience seating with each chair capable of complying with performance requirements without failure or other conditions that might impair the chair's usefulness.
   2. Install standards and pedestals plumb.
   3. Install seating so moving components operate smoothly and quietly.
B. Install floor-mounted standards, beams, and attachments to maintain uniform chair heights above floor.

C. Install base plate with corrosion-resistant expansion anchors into concrete.
   1. Minimum concrete embedment of 1-1/2 inches unless otherwise instructed by seat manufacturer.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Inspect components, assemblies, and equipment, including connections, to verify proper, complete, and sturdy installation according to manufacturer's written instructions and product specifications.
   2. Verify that seats return to correct and uniform at-rest position.

B. Fixed audience seating will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust hardware and moving parts to function smoothly so they operate easily. Lubricate bearings and sliding parts as recommended in writing by manufacturer.

B. Repair minor abrasions and imperfections in finishes with coating that matches factory-applied finish.

C. Replace damaged and malfunctioning components that cannot be acceptably repaired.

END OF SECTION
SECTION 130413 - COMMON SUBMITTAL REQUIREMENTS FOR SPECIAL CONSTRUCTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

   1. Action Codes Permitting Use:

      a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.

      b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.

      c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.

1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.

   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition

   1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.
3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).
4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering
1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS
A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.
B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.
C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.
D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 132300 - PLANETARIUM DOME

PART 1 – GENERAL

1.1 PROJECT DESCRIPTION/WORK INCLUDED

A. The selected contractor shall provide and install a 30’ DIAMETER DOME PROJECTION SCREEN TO SUPPORT A FULLDOME PLANETARIUM PROJECTION SYSTEM (FPPS) and LED LIGHTING SYSTEM for the CCC Planetarium.

B. The dome projection screen design is based on an Astro-Tec Manufacturing Co. 30-foot diameter dome.

Contact: Astro-Tec Manufacturing, Inc.
550 Elm Ridge Avenue, P.O. Box 608, Canal Fulton, Ohio 44614-0608
Phone: (330) 854-2209 | Fax: (330) 854-5376
http://astro-tec.com/contact/

1. Unless otherwise noted, a substituted manufacturer may be proposed and included, but only if Alternate manufacturer meets specifications outlined in PART 2 – 30’ DOME PROJECTION SCREEN and approved in advance by the Architect and the Planetarium Design Consultant.

D. This specification shall apply to all phases of Work hereinafter specified, shown on drawing PL.EQ1 DOME, or as required to provide a complete installation.

1. The Dome details, including vertical suspensions, lateral bracings, locations, mounting details shall be designed to comply with the requirements and details indicated in Architectural and Structural Drawings.

1.2 GENERAL REQUIREMENTS

A. Warranty: Furnish a written guarantee for a period of FIVE years from date of acceptance.

B. The dome projection screen described in this specification shall be furnished and installed by the manufacturer.

C. Before manufacturing, dome provider to provide a certified engineering design study documents showing that the dome meets State of California Seismic requirements. Fabrication and installation of deferred submittal items shall not be started until contractor’s drawings, specifications, and engineering calculations for the actual systems to be installed have been accepted and signed by the architect or structural engineer and approved by the DSA.

1. Verifying Drawings and Job Conditions:
2. Examine all project drawings and specifications to ensure full awareness of all work required under this Section.
3. Visit the site and verify existing conditions. Where existing conditions differ from drawings, report differences to architect and where possible without re-manufacture of dome components, make adjustments and allowances for all necessary equipment to complete all parts of the work. Verify actual dimensions of construction contiguous with Planetarium equipment by field measurements before fabrication.
4. Pre-installation Conferences: Conduct a minimum of one conference at the project site prior to the start of installation work. Where existing conditions differ from drawings, report differences to architect and, where possible without re-manufacture of dome components, make adjustment and allowances for all necessary equipment to complete all parts of the work.

1.3 FINAL INSPECTION AND ACCEPTANCE

A. After all requirements of the specifications and/or the drawings have been fully completed, representatives of the Owner will inspect the work.

B. Final acceptance of the work will be made by the Architect, Owner, and the Planetarium Design Consultant.

1.4 RECORD DRAWINGS

A. Drawings of Record: Provide and keep up-to-date, a complete record set of drawings. Keep these corrected daily and show every change from the original drawings. Keep this set of prints on the job site for use only as a record set. This shall not be construed as authorization for your firm to make changes in the layout without Owner approval in each case.

B. Upon completion of the work, obtain a set of Contract Drawings from the General Contractor and create a record set professionally using a PDF editor. Deliver this set in PDF format as indicated in Submittals – Close-Out, below.

1.5 APPROVALS, EQUALS, SUBSTITUTIONS, ALTERNATIVES, NO KNOW EQUAL

A. Approvals: Where the words (or similar terms) “approved”, “approval”, “acceptable”, and “acceptance” are used, these refer to the requirement that acceptance by the Owner, Architect, Planetarium Design Consultant, and Engineer is required.

B. Equal: Where the words (or similar terms) “equal”, “approved equal”, “equal to”, “or equal by”, “or equal” and “equivalent” are used, it shall be understood that these words are followed by the expression “in the opinion of the Owner, Architect, and Engineer.” For the purposes of specifying products, the above words shall indicate the same size, made of the same construction materials, manufactured with equivalent life expectancy, having the same aesthetic appearance/style (includes craftsmanship, physical attributes, color and finish), and the same performance.

C. Substitution: For the purposes of specifying products “substitution” shall refer to the submittal of a product not explicitly approved by the construction documents/specifications.

1. Substitutions of specified equipment shall be submitted and received by the Architect ten days prior to the bid date for review and written approval. Regulatory Agency approval for all substitutions will be the sole responsibility of the Contractor. To receive consideration, requests for substitutions must be accompanied by documentary proof of its equality with the specified material. Documentary proof shall be in letterform and identify the specified values/materials alongside proposed equal values/materials. In addition, catalog brochures and samples, if requested, must be included in the submittal.
2. SUBSTITUTIONS MUST BE PRE-APPROVED BY THE ARCHITECT AND THE PLANETARIUM DESIGN CONSULTANT. ALL BIDS SHALL BE BASED ON THE PRODUCTS EXACTLY AS SPECIFIED. PRICING FOR EACH APPROVED SUBSTITUTION SHALL BE INCLUDED IN THE BID SUBMITTAL AS A SEPARATE LINE ITEM.

3. The Contractor warrants that substitutions proposed for specified items will fully perform the functions as specified herein.

D. Alternates/Alternatives: For the purposes of specifying products, “alternatives/alternates” may be established to enable the Owner/Architect/Engineer to compare costs where alternative materials or methods might be used. An alternate price shall be submitted in addition to the base bid for consideration. If the alternate is deemed acceptable, written authorization will be issued.

1.6 SUBMITTALS – PRE-CONSTRUCTION

A. Submit the shop drawing submittal as PDF files accompanied by Letter of Transmittal, which shall give a list of the number and dates of the drawings submitted.

B. Provide consecutively numbered drawings featuring the name of the project that indicate the name of the specific staff that checked and approved each drawing. Any drawings submitted without this approval will be rejected.

C. If the shop drawings show variations from the requirements of the Contract because of standard shop practice or other reasons, make specific mention of such variations in the Contractor’s letter of transmittal.

D. Projection Dome vendor/supplier shall not proceed with manufacture of dome without written (via letter, fax or email) acceptance of final submittals by GC, Architect, Planetarium Consultant, and DSA approval of the deferred submittal.

1.7 SUBMITTALS – CLOSE-OUT

A. Subsequent to completing preliminary testing, provide to the Construction Manager, Owner, and Planetarium consultant, a letter/report documenting the results of the preliminary tests and the documentation detailed below. The receipt of this documentation will constitute the acknowledgment that the installation is complete, that it conforms to this specification, and that it is ready to be reviewed and tested.

B. Operation and Maintenance Manuals: Provide all manuals as PDF files on three duplicate CD-ROM disks or USB drives, named consistently with the manufacturer’s name and the model number in separate folders for the planetarium and exhibit hall. Copy the same file and folder organization to the Owner.

   1. Spare materials such as spare dome panels. Include method/conditions of storage.
   2. Dome maintenance and cleaning instructions

C. As-built drawings: Provide all as-built documentation as PDF files on the disks and online service mentioned above. In addition, provide a single copy each of the functional drawings, floor plans, and ceiling plans as laminated full-size drawing sets.
PART 2 - PRODUCTS

2.1 30' DOME PROJECTION SCREEN

A. OVERVIEW: The support of the 30’ diameter dome structure, suspended from roof truss at not less than 12 points and not more than 14 equidistant measured from dome center. Rigid horizontal restraints are also required. Nature of, number of, and location of vertical supports and horizontal restraints must meet California seismic requirements. The weight of the dome without cove trough shall not exceed 3600 pounds. Weight with cove trough, ladders, attached audio speakers, projectors, and cove-lighting shall not exceed 5100 pounds. Refer to schematic level drawing A1.PL DOME.

2.2 SCOPE:

A. The work covered by the specifications consists of furnishing materials, plant labor, equipment necessary to the fabrication, manufacture, delivery, and complete installation of a tilted 30 Ft. (180 degree) hemispherical planetarium projection dome. Target reflectivity: 44% (to be confirmed by planetarium system provider). Dome tilt angle will not exceed 2.5 degrees.

B. Projection surface: Perforated overlapping aluminum sheets with factory prime coat, followed by a final coat of water-based non-bridging flat paint on-site after panel installation.

2.3 WORK INCLUDED

A. STAMPED ENGINEERING STUDY THAT SHOWS THAT DOME MEETS CALIFORNIA STATE SEISMIC REQUIREMENTS AND ENGINEERING CRITERIA/REQUIREMENTS SET BY DSA.

B. Supply of all materials and labor required for the design and manufacture of a hemispherical projection dome with a perforated projection surface of painted aluminum.

C. Preparation of complete shop, assembly and erection drawings, which shall be subject to approval by the owner with respect to general design.

D. Preparation of a list of installation requirements, such as storage of materials, installation conditions (heat, light, power, ventilation, etc.) as well as an estimate of erection time.

E. Attendance of at one job-site co-ordination and scheduling meeting at time of dome delivery or prior to dome installation.

F. Manufacturer's personnel shall install the dome screen.

G. Prior to any manufacturing, provide all samples, procedures and demonstrations as specified for approval by owner.

H. Design and supply of the base tension ring of the dome, including the interface with the structural support ring and anchor bolts/eye bolts provided in the building by the owner.

I. Delivery of all materials, special tools and accessories for the dome projection screen to the site in manufacturer's protective packaging.

J. Provisions of a skilled painter, experienced in on-site painting of dome screens, for the final painting of the dome projection surface.

2.4 REQUIRED SITE PREP WORK BY THE GC

A. Scaffolding and scaffolding platforms are to be provided by the owner/general contractor.
Because the finished floor consists of a number of 4" high risers, the General Contractor will provide a TEMPORARY wooden raised level floor as part of the site preparation. The level platform is required for the rolling towers during installation. The platform must be flat and smooth with a load-bearing surface of at least 80-lbs./sq. ft. Platform material must be 3/4" T&G plywood and screwed in place.

B. Suspension attachment points per shop drawings supplied by dome manufacturer.

2.5 STRUCTURAL INTEGRITY

A. The manufacturer shall provide the owner with a certified drawing or statement of the total weight of the dome and its distribution around the dome base ring which rests on the structural support ring, columns or eyebolts provided by the owner.

B. The manufacturer shall be responsible for the structural design of the complete dome screen systems including the structural frame and panels, sizing of all members and detailing of connections to support structure or eyebolts as supplied by owner.

C. Prior to commencing fabrication, the manufacturer shall provide to the owner design drawings for approval.

2.6 DESIGN AND MANUFACTURE

A. The projection dome shall be self-supporting and capable of maintaining its hemispherical characteristics when supported by its tension ring as required by the design of the theater.

B. The hemispheric shell consists, in part, of an aluminum structural rib network system of twenty-eight (28) evenly spaced ribs, with a depth of not less than 2" and not more than 7" and sufficient number of cross-members to maintain its correct shape. The inside diameter of the dome screen shall be 30’ or 9144 mm, departing not more than plus or minus 12.7mm from the nominal radius.

C. The ribs shall be accurately formed and reinforced in accordance with the manufacturer's drawings. The ribs shall be fabricated from aluminum alloy 6061-T6 and 6063-T5, or other suitable material.

D. A girt system shall be incorporated to maintain proper rib spacing. Sizing and spacing shall be as indicated on manufacturer's drawings as approved by the owner.

E. The structural gage of the dome shall be sufficiently stiff so that deflection and settlement of the structure will not lead to deformation of the screen panels, based on the stiffness of the support system provided by the owner.

F. A circular compression ring shall be provided and located at the zenith or apex of the dome, to accommodate the terminal points for the main ribs and the perforated top circle. The compression ring shall be fabricated from aluminum alloy 6061-T6, or other suitable material acceptable to the owner.

G. An aluminum base tension ring shall be provided at the base of the hemisphere, which shall be so constructed that the ring will support the dome and provide the necessary connection points around its periphery. The base tension ring shall be aluminum alloy 6061-T6 or other suitable material, sized and reinforced in accordance with the manufacturer's drawings.

H. The projection surface shall consist of no more than 57 perforated panels which shall be 0.040 (1mm) gauge aluminum alloy type 5052-H32 containing 0.062 in. (1.6mm) diameter holes on 0.125 in. (3.2mm) staggered centers, to provide approximately 22% void area with a minimum of a 20% void after final painting.
I. The perforated panels shall be formed or stretch-formed over a compound die to correspond to the required section of a sphere. Trimming of the panels to their final configuration shall be accomplished in compound fixtures at manufacturer's factory.

2.7 SEAMS AND JOINTS
A. Seams between adjacent panels will be overlapped jointed.
B. The seams, where the panels join, shall be overlapped by no more than 29mm and shall have an opaque flat black material of minimum thickness between the layers to insure that the reflectivity of the seams matches the rest of the dome screen surface. The panels shall be secured to the ribs using low profile aluminum rivets. Vertical and horizontal seams shall not be located where there are no structural elements available for support. After final painting the dome shall appear nearly seamless under projection from the center of the dome.

2.8 QUALITY ASSURANCE
A. Uniformity of the color and the reflectivity of the dome surface over the entire area of the dome screen are of vital importance. Variation of reflectivity or color from panel to panel shall not be accepted. To this end the dome manufacturer shall include a quality assurance program as an integral part of his proposal. This program shall clearly address the points which follow, as well as any others which the manufacturer considers pertinent.
B. Dome images projected from center of dome shall appear nearly seamless as seen from near the center of the dome.
C. The dome manufacturer shall provide a description of the methodology and equipment to be used to ensure uniformity of color and reflectivity of surface.
D. If any corrective measures are needed, due to color variation or reflectivity they will be made in the final painting of the screen. Any other corrective work needed shall be performed prior to any finish work in the dome room.
E. If for any reasons, satisfactory repairs or touch-up cannot be made to bring the dome screen within the required uniformity, repainting will be performed by the dome manufacturer.

2.9 PREPARATION AND FINISH OF DOME STRUCTURE
A. The structural rib network, girts and pipe-members shall be thoroughly degreased to provide a clean, adhesive surface prior to painting. All structural elements shall be given a factory-applied coat of flat black paint.
B. Any damaged paint on surfaces (caused by shipping) shall be touched up with matching flat black paint before panel installation is started.

2.10 PROJECTION SURFACE OF THE COMPLETED DOME
A. The inside surface of the dome screen is to be painted with the overall reflectivity of 0.44. The seams are to be virtually unnoticeable and the panel-to-panel differences invisible during projection.
B. The screen surface shall diffuse incident light with no spectral component while retaining the specified reflectance, with absence of gloss at all incident angles under projection from the center of the dome.
C. The seam backing material between the panels supplied by the manufacturer must be such that reflectance of the seam areas does not change over a period of at least five (5) years from acceptance.

D. The projection surface is to be factory primed then painted-in-place, by a factory technician with a non-bridging flat coating, with the target reflectivity of 44% (to be confirmed).

2.11 COVE LIGHT TROUGH
A. Per detail shown in shown on drawing E1.PL LIGHTING, Dome manufacturer shall provide a self-supporting cove trough app. 6” deep with a 3” high façade. This trough shall be of sufficient strength to support with no distortion an LED cove light system. This trough shall be bolted to or supported by the dome tension ring.

2.12 EXTENDED COVE TROUGH FOR TRACK LIGHTING
A. Per detail shown in shown on drawing sheet E1.PL LIGHTING, Dome manufacturer shall provide self-supporting cove trough pan or base that extends 2” beyond the tension ring at base of dome to support track fixtures and track lighting. This makes the dome trough Pan app. 15” deep from front to back. This dome trough pan extension shall be of sufficient strength to support with no distortion a track lighting wall-wash system that runs around the theater along the dome tension ring.

2.13 DOME LADDERS
A. Manufacturer shall provide three (3) ladders that conform to the outer ribs of the dome. One ladder shall run from the bottom tension ring to dome zenith compression ring. The other two ladders shall be run from bottom tension ring up to 40 degrees up the dome. Location in dome azimuth of ladders are shown in A1.PL DOME. Final locations shall be confirmed/approved by owner, architect, planetarium consultant before installation.

2.14 ATTACHMENTS TO DOME BY OTHERS
A. All submitted mounts and methods provided by others for lighting equipment, projector, and audio speakers attached to dome structure must be reviewed/approved by the dome manufacturer before manufacture by others. See drawing sheets TE1 SOUND and E1.PL LIGHTING showing desired methods for mounting/attaching equipment by others to dome. ESTIMATED WEIGHT OF DOME LADDERS, EQUIPMENT, EQUIPMENT MOUNTING HARDWARE, LED POWER SUPPLIES, TRACK LIGHTING, CABLING AND THE WEIGHT OF ONE PERSON ON DOME LADDER WILL NOT EXCEED 1500 POUNDS. THIS WEIGHT SHALL BE THE DESIGN CRITERIA FOR SEISMIC ENGINEERING STUDY.

2.15 ACCEPTANCE OF WORK BY OTHERS
A. The architect will provide the dome screen manufacturer complete design information concerning the architectural support for the base tension ring of the dome.

B. The dome manufacturer shall provide a list of site conditions required for installation and conduct a pre-installation site inspection before scheduling the installation.
PART 3 - EXECUTION – NOT USED

END OF SECTION.
SECTION 132310 - PLANETARIUM PROJECTION SYSTEM

PART 1 - GENERAL

1.1 PROJECT DESCRIPTION/WORK INCLUDED

A. The project shall provide, install, train for and support a FULLDOME PLANETARIUM PROJECTION SYSTEM (FPPS) for the CCC Planetarium as shown in schematic and diagrammatic drawings A.1 PL, AV1. BLOCK DRAWING, A1.CONSOLE, and TE1.PL.

B. The Planetarium takes the form of multi-use domed theater and, in addition to astronomy, is also used for general instruction/lecture and visualization by various College Departments including: Science, Engineering, and Math.

C. The design is based on MEDIAGLOBE Σ 2K by Konica Minolta Planetarium Co. and SciDome IQ 2400 by Spitz, Inc.

Contact: Steve Hatfield
KONICA MINOLTA PLANETARIUM CO., LTD.
424 Becky Street Orlando, FL 32824
Tel: +1 321-246-5439
E-mail: steve.hatfield@konicaminolta.com
URL: https://www.konicaminolta.com/planetarium/greetings/index.html

Joyce Towne
Spitz, Inc.
700 Brandywine Drive Chadds Ford, PA 19317
+1 610-459-5200
E-mail: jtowne@spitzinc.com
URL: https://www.spitzinc.com

D. Unless otherwise noted, a substituted component may be proposed and included, but only if approved in advance by the Planetarium Design Consultant and/or the Contra Costa College.

E. This specification shall apply to all phases of Work hereinafter specified, shown on drawing, or as required to provide a complete installation. Work required under this specification, is not limited to just the FPPS - refer to Architectural, Electrical, Structural, and Raceway/Structural Cabling, as well as all other drawing applicable to this project, which designate the scope of work to be accomplished. The intent of the drawings and Specifications is to provide a complete and operable planetarium system that includes all documents that are a part of the Contract.

1. Work Included. Furnish labor, material, services and skilled supervision necessary for the construction, erection, installation, connections, testing, and adjustment of all FPPS equipment specified herein, or shown or noted on drawings, and its delivery to the Owner complete in all respects ready for use.

2. The FPPS work includes installation or connection of certain materials and equipment furnished by others. Verify installation details, installation and rough-in locations from the actual equipment or from the equipment shop drawings.

F. The associated system drawings are diagrammatic and are intended to convey the scope of work, indicating intended general arrangement of equipment. Follow drawings in laying out work and verify spaces for installation of materials and equipment based on actual dimensions of equipment furnished.
1.2 RELATED DOCUMENTS AND SECTIONS

A. Refer to drawings A.1 PL, AV1. BLOCK DRAWING, A1.CONSOLE, and TE1.PL.

1.3 GENERAL REQUIREMENTS

A. Warranty: Furnish a written guarantee for a period of two years from date of acceptance.

B. Documents that your firm is a factory-authorized installer and warrantee station for the brand of equipment offered and maintain a fully-equipped service organization capable of furnishing adequate repair service to the equipment. Maintain a spare set of all major parts for the system at all times. All circuit boards, amplifiers and control sub systems shall be 100% backed up with stock at your firm’s shop.

C. All of the equipment in this specification shall be furnished and installed by the Authorized Factory Installer of the equipment. Furnish a letter from the manufacturer of all major equipment, certifying that your firm is the Authorized Installer and that the equipment has been installed according to factory intended practices.

D. All of the equipment in this specification shall be furnished and installed by the Authorized Factory Installer of the equipment with the most current software and firmware package available at the time of installation. At the time of Owner Acceptance of the installation, all equipment shall include any and all updated software or hardware revisions. In addition, when the software is available in disk format, a backup copy of the most up to date revision, in disk format, shall be handed to Owner at the completion of the project.

E. Verifying Drawings and Job Conditions:
   1. Examine all project drawings and specifications to ensure full awareness of all work required under this Section.
   2. Visit the site and verify existing conditions. Where existing conditions differ from drawings, make adjustments and allowances for all necessary equipment to complete all parts of the work. Verify actual dimensions of construction contiguous with Planetarium equipment by field measurements before fabrication.
   3. Pre-installation Conferences: Conduct a minimum of one conference at the project site prior to the start of installation work. Where existing conditions differ from drawings, make adjustment and allowances for all necessary equipment to complete all parts of the work.

1.4 WORK IN COOPERATION WITH OTHER TRADES

A. Examine the drawings and specifications and determine the work to be performed by the electrical and other trades. Provide the type and amount of audiovisual systems materials and equipment necessary to place this work in proper operation, completely wired, tested and ready for use.

B. Confirm Low voltage conduit, boxes and power have been provided by the division 26 00 00 contractor.
1.5 TESTING AND ADJUSTMENT

A. Upon completion of all audiovisual systems work, provide testing and demonstrating in the presence of the owner’s inspector that the all audio, digital video and control parameters are as stated in the factory data sheets.

B. Promptly repair or replace all equipment and parts discovered to be in need of correction. Then retest that part of the system and all associated components to correct the error. Perform all such replacement or repair at no additional cost to the Owner.

1.6 FINAL INSPECTION AND ACCEPTANCE

A. After all requirements of the specifications and/or the drawings have been fully completed, representatives of the Owner will inspect the work. Provide competent personnel to demonstrate the operation of any item or system to the full satisfaction of each representative.

B. Final acceptance of the work will be made by the Owner after receipt of approval and recommendation of acceptance from each representative.

1.7 RECORD DRAWINGS

A. Drawings of Record: Provide and keep up-to-date, a complete record set of drawings. Keep these corrected daily and show every change from the original drawings. Keep this set of prints on the job site for use only as a record set. This shall not be construed as authorization for your firm to make changes in the layout without Owner approval in each case.

B. Upon completion of the work, obtain a set of Contract Drawings from the General Contractor and create a record set professionally using a PDF editor. Deliver this set in PDF format as indicated in Submittals – Close-Out, below.

1.8 APPROVALS, EQUALS, SUBSTITUTIONS, ALTERNATIVES, NO KNOW EQUAL

A. Approvals: Where the words (or similar terms) “approved”, “approval”, “acceptable”, and “acceptance” are used, these refer to the requirement that acceptance by the Owner, Architect, Planetarium Design Consultant, and Engineer is required.

B. Equal: Where the words (or similar terms) “equal”, “approved equal”, “equal to”, “or equal by”, “or equal” and “equivalent” are used, it shall be understood that these words are followed by the expression “in the opinion of the Owner, Architect, and Engineer.” For the purposes of specifying products, the above words shall indicate the same size, made of the same construction materials, manufactured with equivalent life expectancy, having the same aesthetic appearance/style (includes craftsmanship, physical attributes, color and finish), and the same performance.

C. Substitution: For the purposes of specifying products “substitution” shall refer to the submittal of a product not explicitly approved by the construction documents/specifications.

   1. Substitutions of specified equipment shall be submitted and received by the Architect ten days prior to the bid date for review and written approval. Regulatory Agency approval for all substitutions will be the sole responsibility of the Contractor. To receive consideration, requests for substitutions must be accompanied by documentary proof of its equality with the specified material. Documentary proof shall be in letterform and identify the specified
values/materials alongside proposed equal values/materials. In addition, catalog brochures and samples, if requested, must be included in the submittal.

2. SUBSTITUTIONS MUST BE PRE-APPROVED BY THE ARCHITECT AND THE PLANETARIUM DESIGN CONSULTANT. ALL BIDS SHALL BE BASED ON THE PRODUCTS EXACTLY AS SPECIFIED. PRICING FOR EACH APPROVED SUBSTITUTION SHALL BE INCLUDED IN THE BID SUBMITTAL AS A SEPARATE LINE ITEM.

3. The Contractor warrants that substitutions proposed for specified items will fully perform the functions as specified herein.

D. Alternates/Alternatives: For the purposes of specifying products, “alternatives/alternates” may be established to enable the Owner/Architect/Engineer to compare costs where alternative materials or methods might be used. An alternate price shall be submitted in addition to the base bid for consideration. If the alternate is deemed acceptable, written authorization will be issued.

1.9 SUBMITTALS – PRE-CONSTRUCTION

A. Submit the shop drawing submittal as PDF files accompanied by Letter of Transmittal, which shall give a list of the number and dates of the drawings submitted.

B. Provide consecutively numbered drawings featuring the name of the project that indicate the name of the specific staff that checked and approved each drawing. Any drawings submitted without this approval will be rejected.

C. If the shop drawings show variations from the requirements of the Contract because of standard shop practice or other reasons, make specific mention of such variations in the Contractor’s letter of transmittal. If the substitution is accepted, the Contractor shall be responsible for proper adjustment that may be caused by the substitution. Submit samples upon request.

D. Only products listed as “Equal” within the contract documents, along with formally approved “Substitutions” will be reviewed. Products not conforming to these items will be rejected.

E. Shop drawings shall be submitted on the following but not limited to:
   1. System functional diagrams, including control system wiring and audio signal diagrams
   2. Equipment rack elevations
   3. Console design, layout, equipment placement, etc.
   4. Protective Barrier for Central Projector
   5. Column Lifter
   6. All other products called out on drawings that call for shop drawing submittal

1.10 SUBMITTALS – CLOSE-OUT

A. Subsequent to completing preliminary testing, provide to the Construction Manager, Owner, and Planetarium consultant, a letter/report documenting the results of the preliminary tests and the documentation detailed below. The receipt of this documentation will constitute the acknowledgment that the installation is complete, that it conforms to this specification, and that it is ready to be reviewed and tested.
B. Operation and Maintenance Manuals: Provide all manuals as PDF files on three duplicate CD-ROM disks or USB drives, named consistently with the manufacturer’s name and the model number in separate folders for the planetarium and exhibit hall. Copy the same file and folder organization to the Owner.

1. Provide step-by-step operating instructions for the day-to-day use of the system including power activation, connection of source devices, adjustment of volume levels, selection of sources, etc. Include illustrations and references to individual equipment manuals as necessary.
2. Equipment List: Include an Excel or other spreadsheet file listing all equipment including connectors and specialty hardware. Include columns for manufacturer, model, physical location, MAC address, IP address, if fixed or DHCP, VLAN, serial number, and cable label identification.

C. As-built drawings: Provide all as-built documentation as PDF files on the disks and online service mentioned above. In addition, provide a single copy each of the functional drawings, floor plans, and ceiling plans as laminated full-size drawing sets.

PART 2 - PRODUCTS

2.1 PLANETARIUM FULLDOME DIGITAL PROJECTION SYSTEM

A. General Characteristics:

1. The system shall be a single projector/single lens digital planetarium projector, located along the optical axis of the projection dome as shown in drawing A1.PL. System will include a column LIFTER to raise the Fulldome Projector when in use and lower it into a barrier when not in use. Supplier shall include Control Console and Projector Barrier casework as shown in drawing: A1.CONSOLE.

2. There shall be no apparent image seams or blending artifacts, variation in color, and variation in brightness across the dome over the entire life of the Planetarium projector system. Minimum White-light Dome Image brightness on a 30’ diameter dome with reflectivity of 44% is one (1) Foot Lambert (F.L.). Brighter is acceptable.

3. The projector system shall be capable of playing all formats of fulldome movies.

4. The system shall have an extensive set of astronomical databases.

5. The system shall have both manual and wireless controls. The manual controls shall be located at a fixed console (see). The wireless touch-screen remote control shall operate anywhere in the planetarium theater.

6. The proposed System shall allow for maintenance/repair by planetarium staff with no projector/pixel alignments (electronic or mechanical) required during life of system.

7. The Minimum Effective Dome Master Resolution of the projector image shall be: 2160 pixels (higher acceptable) or 3.664,354 total dome pixels (higher is acceptable).

8. The projection system shall use an azimuthal equidistant projection (circular fisheye) method to insure the accuracy of the fulldome master. Projection angle is 160°±2.

9. LIFTER shall be secured to floor of projector pit and controlled via a wired paddle at the Console. Exact height and travel distance to be determined by the FPPS provider as shown in drawing A1.PL. Current design is based upon 700mm travel distance. Lifter is to lower projector out of slight-lines for whiteboard instructions as shown in A1.PL

B. Technical Specifications:

1. Required Projector Features

   a. Main Configuration: Single-projector system inclusive of lens/chassis/outer cover

   b. Projection technology: LCOS
c. Minimum projector characteristics
   1) Minimum chipset resolution: 4096 x 2160 pixels x 3 chip (can be higher)
   2) Minimum number of colors: 16,770,000 colors (10 bit color depth)
   3) Minimum rated light output: 4000 Lumens at 100%
   4) Minimum native on/off contrast ratio: 15,000:1
   5) Be capable of displaying 60 fps movies.

d. Projection Lens: 160 degree ± 2° projection angle. All lens elements shall be fully multi-coated

e. Electrical Power: Projector shall be able to operate with AC100～240V at 50/60Hz
   and electrical load less than 15 amps.

2. Computer Features
   a. Graphics Card output shall be capable of 24 fps, 30 fps, and 60 fps (frames per second) at the required projected resolution with enough built-in buffer memory to provide smooth display of both real-time generated planetarium imagery and pre-rendered content. The card shall be capable of displaying imagery at 10-bit color depth.
   b. The server shall meet the following minimum specifications: CPUs: 6 core Xeon 3.5GHz or faster, OS: Windows 10 - 64bit or later, Memory per CPU: 8GB or more, Solid State OS Drive (256GB or larger), HDD for Program/Content: 1TB or larger. The vendor shall supply the latest model available of hardware and software version at time of installation. The vendor shall provide cut sheets and shop drawings of the computer system for approval by CCC, prior to installation.
   c. Audio output: The system shall be capable of two-channel, and 5.1-channel source content and shall provide audio over digital output.
   d. Power: AC100～240V, 50/60Hz, Maximum load per computer/server – 1000 Watts or 8.5 amps.
   e. All computer components, switchers, and image/audio processors are to be rack mounted in the Control Console.

3. Live Capture Capability and External Switcher System
   a. The server system shall include a 2K 60 fps HDMI 2.0 “Live Capture” board, allowing the Digital Fulldome Planetarium system to display real-time streaming images from external computers/laptops, IP cameras, observatory cameras, etc.
   b. Vendor shall include a real-time switcher unit that will allow the operator to switch the image/computer source of the Digital Fulldome Projection System. This switcher shall support seamless switching frame-to-frame video (no transition time) and shall not send a blue screen or any image to the Digital Fulldome Projectors during the switching process. Image overlap and warp must match that of the Digital Fulldome Projection System.

4. Signal Distribution:
   a. The vendor shall supply of all signal switching and cabling systems associated with the Fulldome Planetarium system from all image sources including the secondary image generator. Please refer to AV1. BLOCK DRAWING.
   b. Vendor is to include all control and switching equipment, cabling, etc. in the system, capable of displaying signals from both vendor supplied systems and alternate owner furnished fulldome systems as well as presentation PC, laptop presentations and the remote telescope cameras. Digital video signals shall be utilized throughout the system to achieve a truly digital system throughout.
   c. Signal distribution equipment shall include, but is not limited to, boosters, transmitters and receivers shall be all digital in terms of signal path and provided as required to ensure all signal distribution runs are within the specification of the maximum run for the signal type. All digital picture continuous signal runs of more than 20 meters shall
be done via optical fiber.

C. Digital Planetarium Functions:

1. At the planetarium control console, the planetarium system shall provide a simple-to-use GUI that allows the operator to display the following functions in real-time or through pre-recorded macro functions:

2. Fixed Stars:
   a. Stellar Data Base shall include the Hipparcos Catalogue and the Bright Star Catalogue down to 13.1 magnitude (more than 110,000 fixed stars).
   b. The system shall be able to adjust brightness of stars (0-100%).
   c. The Limiting Magnitude shall be adjustable in 0.1 magnitude increments.
   d. Display of the datasets shall be adjustable by distance from Earth in light-year increments.
   e. Display of the datasets shall be adjustable by spectral class and luminosity class.
   f. The system shall be able to change the texture/artwork/color of stars.
   g. The system shall be able simulate scintillation/twinkling of stars (with the characteristics of scintillation adjustable by the user)
   h. The System shall be able simulate major supernovae and the light curves of variable stars with apparent magnitude 6.5 or brighter.
   i. The system shall be able to display telescopic photos of Supernova. The user shall be able to add images, as needed.
   j. The system shall be able simulate representation of proper motion over a period ±1,000,000 years.
   k. System shall be able trace the path of stellar objects.
   l. User shall have the ability to customize the visual size (angular size or diameter) of fixed stars according to their magnitude.
   m. The User shall have the ability to customize the visual color of fixed stars according to their interpretation of the color index/spectral class.
   n. In displaying the sky as seen from the surface of the Earth, the center of individual stars shall have a positional accuracy as measured at any or every location of the 30’ diameter dome screen of less than ±10 arc minutes as measured from the center of the dome.
   o. The user shall have the ability to turn ON/OFF the aureole of Sun.
   p. The user shall have the ability to turn ON/OFF daylight, moonlight, and light pollution.

3. Galaxies, Nebulae and Star Clusters:
   a. The system shall show the Milky Way with individual selection for Visible/Infrared/X-ray/Gamma-ray/Radio Continuum, Hydrogen Alpha, Atomic Hydrogen, and Molecular Hydrogen. Brightness adjustment shall be from 0-100%, independent of fixed stars, using a slide bar control.
   b. The system shall show all Messier objects including selectable display of location marker, label (English), and display of enlarged telescopic image (picture). Images should be mapped to celestial sphere in the proper orientation and shall participate in Earth motions.
   c. The system shall allow the ability to add close-up photos of main Galaxies, cluster of galaxies, nebulae, planetary nebulae, dark nebulae, globular clusters, open clusters, etc. The system shall Display galaxies, nebulae, star clusters from any location in known universe.
   d. The system shall display Asteroid belt objects, Kuiper belt objects, Oort cloud, globular clusters, Local Group, regional galaxies, SDSS, quasar survey, WMAP and Planck Map of early universe. The system shall display labels of objects.

4. Solar System:
   a. The system shall display:
1) The Sun: Enlarged display and shall display Total, Annular, and Partial Solar Eclipses, including the Diamond Ring effect and the Solar Corona.
2) The Moon: Enlarged display including representation of Moon phases and Earthshine and shall display Total and Partial Lunar Eclipses, including the reddening of the Moon during eclipse.
3) Be able to scale up or down the Sun, the Moon, planets and etc. individually or in synchronization.
4) All planets and Pluto: Enlarged display, display of label, display of orbit.
5) All named dwarf planets: Enlarged display, display of label, display of orbit.
6) Major Trans-Neptunian objects: Display of label, display of orbit.
7) Minor Planetary Satellites: Enlarged display, display of label display of orbit.
8) Minor objects (minor planets, asteroids and comets): Display as a dot, display of label, display of orbit. Ability to add artwork, close-up photos of Asteroids, Comets.
9) Spacecraft: Display of Pioneer 10 and 11, Voyager 1 and 2, Cassini, New Horizons, etc. and their orbits.
10) Project the paths of seasonal Suns and trace the Analemma.

5. Simulation Range, Time, and Viewpoints:
   a. Time:
      1) Display proper motion of fixed stars over ± 1,000,000 years.
      2) Display all Solar System Objects motion over ±100,000 years.
   b. Space: to distant objects formed in early universe.
   c. Time Setting:
      1) Any time within the simulation range
      2) System shall have the ability to be customize time settings at startup by the user.
   d. View point (in the solar system):
      1) On any object at any latitude, longitude and planet-centric distance.
      2) Able to select and move solar system objects.
      3) Ability to move forward to/backward from/around solar system objects. (moving speed can be selected or automatically preset.)
      4) View point (outer space):
      5) Able to display the day or night sky viewed from a given target or location. Ability to automate, record, and store space travel from take-off to arrival point by setting up objects to seen en route, final target object, duration time of travel, etc.

6. Meteors and Meteor Showers:
   a. Sporadic Meteors: Real time simulation. Meteors can be displayed out of synchronization with time.
   b. Meteor Streams: Real time simulation with accurate peak/radiant points. User can set the meteor rate.

7. Coordinate Systems:
   a. Display of horizontal coordinates, equator, right ascension and declination, ecliptic, ecliptic latitude and longitude, galactic coordinates, super galactic coordinates, galactic longitude and latitude, meridian, azimuth, precession circle, poles, ecliptic pole, and zenith point.
   b. Able to Display distance circles or spheres from the sun (scale) in off-Earth simulations.

8. Constellations:
a. Display Artworks: Display of 88 constellation artworks individually or in any combination.
b. Display Lines: Display of 88 constellation lines individually or in any combination. The lines shall display in 3-dimensional location when viewed off of Earth's surface.
c. Display Boundaries: Display of boundaries of 88 constellations individually or in any combination.
d. Display Labels: Display of labels for 88 constellations individually or in any combination.
e. Display Animation Constellation Artworks. Operator will have the ability to add alternate constellation artwork and additional animated constellations.
f. Lines, Boundaries, Labels shall be adjustable by color/line width/size, font etc.

9. Asterisms:
   a. Major Asterisms: Great Spring Triangle, Great Spring Arc, Spring Diamond, the Big Dipper, Finding Polaris by using the Big Dipper, Leo’s Scythe, Summer Triangle, Northern Cross, Tea Pot, The Milk Dipper, Great Square of Pegasus, Finding Polaris by using Cassiopeia, Winter Triangle, Great Diamond or Hexagon of Winter, Winter circle, the False Cross, Winter "W", How to find the South Pole, etc.

10. Pointers, lines, circles, etc.:
    a. Able to display multiple pointers at a time including arrow, circle, cross and others anyplace on the dome. Display lines or letters connecting given points on the screen. Able to display lines that follows mouse/pointer movement.

11. Natural Sky Phenomena:
    a. Morning/evening twilight - real time simulation (automatic brightness control based on the location of the Sun)
    b. Sunset/Sunrise clouds
    c. Representation of natural phenomena including lighting, clouds, rain, snow, aurorae, fireball, zodiacal light, gegenschein and etc.
    d. Daylight and Blue Light: The brightness is automatically adjusted in relation to the location of the Sun.

12. Panorama (Landscapes):
    a. Able to display day/night landscapes (panoramas). Easily change to other layers or landscapes. Vendor shall supply a minimum of 10 panoramas in the database as well as one local photographic panorama of local campus area to be determined by CCC. Synchronized brightness control based on the altitude of the Sun.
    b. Able to display scenes (day view and night views) created by CCC staff.

13. High Resolution Surface Mapping:
    a. Able to display high-resolution surface map images for Mercury, Venus, Earth, Moon and Mars in real-time simulation. Still images can be pasted at a specified longitude and latitude, in proper orientation, and displayed on the surface.

14. Data2Dome:
    a. Vendor is to provide a pathway to import and display astronomical data through the Data2Dome project as proposed by ESO. CCC recognizes that this is a work in progress, but the vendor, through the warranty period, must update its software to import these datasets as they become available.

15. Multimedia Functions:
    a. The system shall provide the following functions:
1) Fulldome Projection:
   a) Fulldome projection of stills or movies.
   b) Fulldome projection can be performed with the planetarium functions or other multimedia functions.

2) Still Images:
   a) Multiple still images can be projected simultaneously and can be switched automatically in specified intervals. Operator can move, zoom, fade and special effects (rotation, wiping, etc.) still images.
   b) Able to display these file formats: BMP, JPEG, PNG, TIFF, TGA, GIF and PICT.

3) Movies:
   a) Multiple movies can be projected simultaneously. Operator can Play / Stop / Pause / Repeat / Move / Zoom / Fade any or all movies as well as Search and Load new movies in real time.
   b) Able to display these formats: MPEG, AVI, WMV, MP4, MOV, FLV

4) Sounds
   a) Multiple sound files can be played simultaneously. Operator can Play / Stop / Pause / Repeat / Fade any or all sounds as well as Search and Load new sounds in real time. Able to play these formats: WAV (2 ch. to 5.1), MP3, AC3, WMA, and OGG.

5) 3D Object:
   a) Multiple 3D objects can be projected simultaneously.
   b) Able to display these formats: Lightwave Object (.lwo), 3D Studio Max (.3ds)

6) Text and Others:
   a) Letters can be projected as text data. 2-dimensional objects such as dots, lines, circles, arrows and freely drawn lines and can be projected in real-time.

7) Slide show:
   a) Place audio, still images, and/or video on a timeline, and play/record automatically.

8) Live Capture:
   a) Project the HDMI output image of an external device. Automatic distortion correction of live action or real-time images on any part of the dome.

9) Cursor:
   a) Display a dome-view cursor, size/type/artwork of cursor can be customized by users.

10) Macro Function:
    a) Operator can record, reproduce, and edit the contents of all manually operated planetarium and multimedia functions to create programs.
    a) Recorded macros can be edited along a time-line or converted to a script program for even more precise editing and show production.
11) Other:
   a) Ability to render out dome master frames
   b) Ability to re-render and encode fulldome movies from dome master frames

D. Requirements and Considerations:

1. Additional Spare Parts: Bidder should provide a list of spare parts provided to maintain continued operation of the system.
2. As a minimum, the following items shall be supplied:
   a. Two complete sets of spare lamps.
   b. Spare hard drives for all computers in system. These hard drives shall be true backups of all provided software at the time of acceptance.
3. The RFP response should provide service spare equipment location and the location of service technicians.
4. Selected vendor is to provide drive cloning device(s) as part of the provided technology. As part of the training, vendor and owner’s representative will jointly develop a schedule/procedure for updating and cycling of back-up and master hard drives.
5. Coordination with GC and other Trades
   a. The selected vendor shall be flexible in the approach to the installation; there will be coordination with other specialists working on site in the same areas. Agreements will be established for allowing sufficient ‘dark time’ to enable proper projection alignment; this may involve working outside normal daytime working hours.
6. Pre-response Site Visit
   a. There will be a job walk to visit the new planetarium site for inspection before responding to this RFP. CCC will facilitate such a visit, however, the cost of the visit will be at the expense of the bidder and technical questions will not be answered on site. All questions shall be presented during the question period as detailed in the RFP.
7. Cabling Considerations
   a. All cabling within the rack housings will be identified, secured and correctly terminated in accordance with manufactures recommendations.
   b. No cable will be stressed and will be installed in such a way that any piece of hardware can be removed from the rack without removing any cable fixings.
   c. All site cables will be neatly installed and secured and enclosed in the containment provided unless stated otherwise.
   d. Any cable splicing or joining will not be accepted. All cable runs to be a single length of cable.
   e. All cables will be identified at both ends in accordance with the delivered Operational and Maintenance (O&M) Manuals.
   f. All audio cables will be of professional audio quality and where applicable will be Oxygen Free Cables (OFC). If video cable run distance exceeds 20 meters, then fiber optic cables will be substituted for copper conductor cables.
8. The system will be complete and any items needed to ensure the required operation of the system will be included on the Bid Pricing. Items required that are not included in the specification should be included in the design and price submitted. CCC will not accept responsibility for omissions in the systems proposed, once a contract is awarded.
9. Warranty:
   a. All provided technology and systems shall be warranted to comply with this specification and shall be free of defects in materials and workmanship for a period of
two years from the date of acceptance.

10. Services:
   a. In addition to the complete engineering design, all labor and materials required for, or reasonably incident to, the manufacture, delivery, on-site supervision, and installation of all the systems and technology detailed in this RFP shall be included.
   b. Vendor’s proposal shall include a fixed price, including all travel and all expenses.
   c. Vendor will be responsible for providing all tools, equipment and materials required to complete the delivery of this specified product.
   d. For the purposes of this proposal, assume that you will be responsible for all off-loading and handling the components and equipment that you deliver to site.
   e. Installation supervision by vendor shall be included if a sub-contractor is used for installation.

11. Training:
   a. After completion of the installation, the contracted vendor will carry out full training on the system(s), including; fault finding, critical parts replacement, maintenance and daily checks and tests. This training will be conducted on site with up to four persons from CCC.
   b. The contracted vendor shall provide an additional 5 days operational training on the Fulldome Planetarium system for up to four persons from CCC. The selected Vendor is to submit a training syllabus to CCC for input/approval. Training will include, but is not limited to, production and installation of Content and Lesson Production.
   c. A training schedule will be developed with CCC to allow for training on the full dome system of the planetarium technology package that will allow for appropriate groups of personnel to be scheduled for training on the various subsystems. Training shall be of sufficient duration and depth and the schedule shall allow adequate time for personnel to absorb the training.

12. Pre-installed Content and Lesson Production:
   a. Fulldome Vendor will install “free” and open source content including but not limited to “Two Small Pieces of Glass” (National Science Foundation), ESO productions (“Mayan Archaeoastronomy: Observers of the Universe”, “Out There - The Quest for Extrasolar Worlds”, “Seeing”, “Phantom of the Universe”, “The Dark Matter Mystery: Exploring a Cosmic Secret”, “The Hot and Energetic Universe”, “From Earth to the Universe”, “Aurora Storm”, “New Horizons for A Distant Planet”), and short films from NASA, JPL and Space Telescope Science Institute (http://www.spacetelescope.org/videos/archive/category/fulldome/). District shall obtain licenses for performance before these installed programs can be shown.

PART - EXECUTION – NOT USED

END OF SECTION
SECTION 132315 - INSTRUCTIONAL PLANETARIUM MEDIA SYSTEMS (IPMS)

PART 1 – GENERAL

1.1 PROJECT DESCRIPTION/WORK INCLUDED

A. Please refer to diagrammatic and schematic level drawings A.1 PL, AV1. BLOCK DRAWING, A1.CONSOLE, and TE1.PL as well as attached specified equipment cut sheets. The selected contractor shall provide, install, train for, and support the following instructional media systems (IPMS):

1. INSET DOME PROJECTION SYSTEM. WUXGA projector produces a partial dome projection app. 8' high x 16' wide.

Specified Model: Panasonic PT-EZ770 with mount attached to dome tension ring

2. ULTRA-SHORT THROW PROJECTION SYSTEM. This is an Ultra Short-Throw (0.23 ratio) Projector for roll-down screen. Native Resolution is 1920 x 1080.

Specified Model: Viewsonic LS830 with wall mount PJ-WMK-304 Universal Wall Mount Kit

3. Two (2) 65" wall-mounted monitors

Specified Model: Panasonic TH-65SF2U

4. Roll-down electric screen for 52” x 92” (16:9) image

Specified Model: DA-LITE Tensioned Advantage Deluxe Electrol screen- DaMat surface -52” x 92”

5. 6 IN/4 OUT MEDIA MATRIX/ROUTING SWITCHER - for distributing six video/data sources with four outputs

Specified Model: Crestron DM-MD6X4

B. The Planetarium takes the form of multi-use domed theater and, in addition to astronomy, is also used for general instruction/lecture and visualization by various College Departments including: Science, Engineering, and Math.

C. Unless otherwise noted, a substituted component may be proposed and included, but only if approved in advance by the Planetarium Design Consultant and/or the Contra Costa College.

D. This specification shall apply to all phases of Work hereinafter specified, shown on drawing, or as required to provide a complete installation. Work required under this specification, is not limited to just the (IPMS - refer to Architectural, Electrical, Structural, and Raceway/Structural Cabling, as well as all other drawing applicable to this project, which designate the scope of work to be accomplished. The intent of the drawings and Specifications is to provide a complete and operable planetarium system that includes all documents that are a part of the Contract.

1. Work Included. Furnish labor, material, services and skilled supervision necessary for the construction, erection, installation, connections, testing, and adjustment of all IPMS equipment specified herein, or shown or noted on drawings, and its delivery to the Owner complete in all respects ready for use.
2. The IPMS work includes installation or connection of certain materials and equipment furnished by others. Verify installation details, installation and rough-in locations from the actual equipment or from the equipment shop drawings.

E. The associated system drawings are diagrammatic and are intended to convey the scope of work, indicating intended general arrangement of equipment. Follow drawings in laying out work and verify spaces for installation of materials and equipment based on actual dimensions of equipment furnished.

1.2 RELATED DOCUMENTS AND SECTIONS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

B. Division 06 sections for the construction of a custom audiovisual console for racks, cabling, wiring, devices, controls, adapters, etc. and other material and equipment required to complete the IPMS.

C. Division 26 sections for connections to fire-alarm systems, wiring, disconnect switches, and other electrical materials required to complete the IPMS.

D. Division 27 sections for communications racks, cabling, wiring, devices, adapters, etc. and other electrical materials required to complete IPMS.

1.3 GENERAL REQUIREMENTS

A. Guarantee: Furnish a written guarantee for a period of two years from date of acceptance.

B. All of the equipment in this specification shall be furnished and installed by the Authorized Factory Installer of the equipment with the most current software and firmware package available at the time of installation. At the time of Owner Acceptance of the installation, all equipment shall include any and all updated software or hardware revisions. In addition, when the software is available in disk format, a backup copy of the most up to date revision, in disk format, shall be handed to Owner at the completion of the project.

C. Verifying Drawings and Job Conditions:

1. Examine all project drawings and specifications to ensure full awareness of all work required under this Section.

2. Visit the site and verify existing conditions. Where existing conditions differ from drawings, make adjustments and allowances for all necessary equipment to complete all parts of the work. Verify actual dimensions of construction contiguous with Planetarium equipment by field measurements before fabrication.

3. Pre-installation Conferences: Conduct a minimum of one conference at the project site prior to the start of installation work. Where existing conditions differ from drawings, make adjustment and allowances for all necessary equipment to complete all parts of the work.

1.4 WORK IN COOPERATION WITH OTHER TRADES

A. Examine the drawings and specifications and determine the work to be performed by the electrical and other trades. Provide the type and amount of audiovisual systems materials and equipment necessary to place this work in proper operation, completely wired, tested and ready for use.

B. Confirm Low voltage conduit, boxes and power have been provided by the division 26 00 00 contractor.

1.5 TESTING AND ADJUSTMENT
A. Upon completion of all audiovisual systems work, provide testing and demonstrating in the presence of the owner's inspector that the all audio, digital video and control parameters are as stated in the factory data sheets.

B. Promptly repair or replace all equipment and parts discovered to be in need of correction. Then retest that part of the system and all associated components to correct the error. Perform all such replacement or repair at no additional cost to the Owner.

1.6 FINAL INSPECTION AND ACCEPTANCE

A. After all requirements of the specifications and/or the drawings have been fully completed, representatives of the Owner will inspect the work. Provide competent personnel to demonstrate the operation of any item or system to the full satisfaction of each representative.

B. Final acceptance of the work will be made by the Owner after receipt of approval and recommendation of acceptance from each representative.

1.7 RECORD DRAWINGS

A. Drawings of Record: Provide and keep up-to-date, a complete record set of drawings. Keep these corrected daily and show every change from the original drawings. Keep this set of prints on the job site for use only as a record set. This shall not be construed as authorization for your firm to make changes in the layout without Owner approval in each case.

B. Upon completion of the work, obtain a set of Contract Drawings from the General Contractor and create a record set professionally using a PDF editor. Deliver this set in PDF format as indicated in Submittals – Close-Out, below.

1.8 APPROVALS, EQUALS, SUBSTITUTIONS, ALTERNATIVES, NO KNOW EQUAL

A. Approvals: Where the words (or similar terms) “approved”, “approval”, “acceptable”, and “acceptance” are used, these refer to the requirement that acceptance by the Owner, Architect and Engineer is required.

B. Equal: Where the words (or similar terms) “equal”, “approved equal”, “equal to”, “or equal by”, “or equal” and “equivalent” are used, it shall be understood that these words are followed by the expression “in the opinion of the Owner, Architect, and Engineer.” For the purposes of specifying products, the above words shall indicate the same size, made of the same construction materials, manufactured with equivalent life expectancy, having the same aesthetic appearance/style (includes craftsmanship, physical attributes, color and finish), and the same performance.

C. Substitution: For the purposes of specifying products “substitution” shall refer to the submittal of a product not explicitly approved by the construction documents/specifications.

1. Substitutions of specified equipment shall be submitted and received by the Engineer ten days prior to the bid date for review and written approval. Regulatory Agency approval for all substitutions will be the sole responsibility of the Contractor. To receive consideration, requests for substitutions must be accompanied by documentary proof of its equality with the specified material. Documentary proof shall be in letterform and identify the specified values/materials alongside proposed equal values/materials. In addition, catalog brochures and samples, if requested, must be included in the submittal.

ONLY PRE-BID APPROVED PRODUCTS, ISSUED VIA A FORMAL BID ADDENDUM TO ALL BIDDERS, WILL BE ALLOWED ON THE PROJECT. REGARDLESS OF THE APPROVAL ON ANY SUBSTITUTION, ALL BIDS SHALL BE BASED ON THE PRODUCTS
EXACTLY AS SPECIFIED. PRICING FOR EACH APPROVED SUBSTITUTION SHALL BE INCLUDED IN THE BID SUBMITTAL AS A SEPARATE LINE ITEM.

2. The Contractor warrants that substitutions proposed for specified items will fully perform the functions required.

D. Alternates/Alternatives: For the purposes of specifying products, “alternatives/alternates” may be established to enable the Owner/Architect/Engineer to compare costs where alternative materials or methods might be used. An alternate price shall be submitted in addition to the base bid for consideration. If the alternate is deemed acceptable, written authorization will be issued.

E. No Known Equal: For the purposes of specifying products, “No Known Equal” shall mean that the Owner/Architect/Engineer is not aware of an equivalent product. The Contractor will need to submit a “Substitution” item, per the requirements listed above, if a different product is proposed to be utilized.

1.9 SUBMITTALS – PRE-CONSTRUCTION

A. Submit the shop drawing submittal as PDF files accompanied by Letter of Transmittal, which shall give a list of the number and dates of the drawings submitted.

B. Provide consecutively numbered drawings featuring the name of the project that indicate the name of the specific staff that checked and approved each drawing. Any drawings submitted without this approval will be rejected.

C. If the shop drawings show variations from the requirements of the Contract because of standard shop practice or other reasons, make specific mention of such variations in the Contractor’s letter of transmittal. If the substitution is accepted, the Contractor shall be responsible for proper adjustment that may be caused by the substitution. Submit samples upon request.

D. Only products listed as “Equal” within the contract documents, along with formally approved “Substitutions” will be reviewed. Products not conforming to these items will be rejected.

E. Shop drawings shall be submitted on the following but not limited to:

1. System functional diagrams, including control system wiring and audio DSP processing chain
2. Equipment locations and methods for mounting
3. Console layout, equipment placement, etc.
4. All other products called out on drawings that call for shop drawing submittal

1.10 SUBMITTALS – CLOSE-OUT

A. Subsequent to completing preliminary testing, provide to the Construction Manager, Owner, and Planetarium consultant, a letter/report documenting the results of the preliminary tests and the documentation detailed below. The receipt of this documentation will constitute the acknowledgment that the installation is complete, that it conforms to this specification, and that it is ready to be reviewed and tested.

B. Operation and Maintenance Manuals: Provide all manuals as PDF files on three duplicate CD-ROM disks or USB drives, named consistently with the manufacturer’s name and the model number in separate folders for the planetarium and exhibit hall. Copy the same file and folder organization to the Owner.

1. Provide step-by-step operating instructions for the day-to-day use of the system including power activation, connection of source devices, adjustment of volume levels, selection of sources, etc. Include illustrations and references to individual equipment manuals as nec-
essay. Hyperlink the references to the individual operation manual files included in this submission.

2. Organize the manual PDF files into folders by subsystem: audio, video, control, etc.

3. Equipment List: Include an Excel or other spreadsheet file listing all equipment including connectors and specialty hardware. Include columns for manufacturer, model, physical location, MAC address, IP address, if fixed or DHCP, VLAN, serial number, and cable label identification.

C. As-built drawings: Provide all as-built documentation as PDF files on the disks and online service mentioned above. In addition, provide a single copy each of the functional drawings, floor plans, and ceiling plans as laminated full-size drawing sets.

PART 2 - SYSTEM EQUIPMENT SPECIFICATION

2.01 PLANETARIUM INSTRUCTIONAL AND EVENT PRESENTATION SYSTEM

A. This is provision and installation of a fully integrated instructional/classroom/event video/graphic system capable of projecting computer data graphics and text in addition to distance learning recording, streaming, and video conferencing. Please refer to drawings A.1 PL, AV1. BLOCK DRAWING, A1.CONSOLE, and TE1.PL. The selected contractor shall provide, install, train for, and support the following instructional media systems (IPMS):

1. INSET DOME PROJECTION SYSTEM. WUXGA projector produces a partial dome projection app. 8’ high x 16’ wide.

Specified Model: Panasonic PT-EZ770 with mount attached to dome tension ring

2. ULTRA-SHORT THROW PROJECTION SYSTEM. This is an Ultra Short-Throw (0.23 ratio) Projector for roll-down screen. Native Resolution is 1920 x 1080.

Specified Model: Viewsonic LS830 with wall mount PJ-WMK-304 Universal Wall Mount Kit

3. Two (2) 65” wall-mounted monitors

Specified Model: Panasonic TH-65SF2U

4. Roll-down electric screen for 52” x 92” (16:9) image

Specified Model: DA-LITE Tensioned Advantage Deluxe Electrol screen- DaMat surface -52” x 92”

5. 6 IN/4 OUT MEDIA MATRIX/ROUTING SWITCHER - for distributing six video/data sources with four outputs

Specified Model: Crestron DM-MD6X4

Please see attached cut sheets for above specified equipment

B. At the lab table location, the IPMS shall have connections vis to adjacent floor box location.
C. Video input and output from source devices to displays and projectors is achieved through routing of the matrix switcher.

D. System displays:

1. Two data projectors one if front projecting on roll-down screen and one at the rear of the theater projecting on the dome screen (see 2.0.1 numbers #1 and #2)
2. Two 65" wall mounted LED displays see (see 2.0.1 numbers #3)
3. Fulldome Planetarium display located in center of theater and controlled at theater control console. Coordinate with Planetarium system provider.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION DESCRIPTION

A. Install Planetarium equipment level and plumb, according to manufacturer's written instructions and drawings from Planetarium Technology Consultant. The installation, configuration and wiring of the system shall be executed in accordance with the drawings and the equipment manufacturer's installation instructions and guidelines. Should any variations in these requirements occur, the Contractor shall notify the architect before making any changes. It shall be the responsibility of the factory-authorized installer of the approved equipment to install the equipment and guarantee the system to operate as per plans and specifications.

B. Complete equipment assembly and termination where field assembly is required.

D. Install equipment with access and maintenance clearances that comply with manufacturer's written installation instructions and with requirements of authorities having jurisdiction.

3.02 GENERAL TESTING REQUIREMENTS

A. Provide all instruments for testing and demonstrating in the presence of the owner's inspector that the all Audio, Digital Video and Control parameters are as stated in the factory data sheets. Check all circuits and wiring to verify they are free of shorts and grounds.

B. VOM shall be used to test continuity and phase of all new wiring and connections with the understanding that the system will function fully as designed.

C. Control functions shall be checked for proper operation, from controlling devices to controlled devices.

D. Adjust, balance, and align equipment for optimum quality and to meet the manufacturer's published specifications. Establish and mark normal settings for each level control with permanent machine printed labeling and provide in system documentation.

E. Controls: Adjust all controls to achieve the specified performance. Provide shaft-locks or covers for all level controls, as appropriate to prevent unauthorized gain changes. Confirm that all control system operations are properly programmed and repeatable.

F. Testing Report: Provide a letter/report documenting the results of these preliminary tests, including amplifier gain/level settings, crossover filter settings, and equalization curves for review by the AV Design Consultant.
G. Verify the following before beginning actual tests and adjustments on the System:

1. All electronic devices are properly grounded.
2. All powered devices have AC power from the proper circuit. All dedicated AC power circuits are properly wired, phased, and grounded.
3. Insulation and shrink tubing are present where required. All exposed bare wire shall be clear shrink wrapped or terminated within the phoenix block. NO exposed bare wire.
4. Dust, debris, solder splatter, etc. is removed.
5. All cable is dressed, routed, and labeled; all connections are properly made and consistent with regard to polarity.

H. Cable and Fiber.

1. Test all cables as installed for shorts between conductors or to building ground and for opens.
2. Certify all data cables installed to Category 6 standards or better.
3. Document all tests and complete measurement results including wire number, date, test equipment used, operator, and test results. If any problems are detected in testing, correct the problem, and retest.

I. Video System Tests:

1. Verify performance of all video connecting cables, as specified herein. Continuity tests are not acceptable. Replace any defective cable prior to continuing testing.
2. Perform video signal parameter tests on individual items of equipment, and the work as a whole in accordance with EIA, SMPTE and AES Recommended Practices and other recognized standards as listed under REFERENCES.
3. Provide full flat panel monitor display calibration and adjustments for optimal picture quality for a single HDMI input. Provide proper aspect ratio configuration for both 16:9 and 16:10 sources. Use a test generator for all setup verification, and verify proper image configuration with all inputs. (Contact the Owner’s Technical Representative prior to final adjustment to coordinate).
4. Projection Systems:
   a. Luminance testing consistent with performance of specified projectors and screens.
   b. Brightness, convergence per ANSI standard procedures for device.
   c. Measure nine points of illuminance per screen and calculate average value in lumens.
   d. High-bandwidth Digital Content Protection (HDCP) check
5. At spaces with HDMI transmission:
   a. Run HDCP check to ensure all devices are HDCP compliant.
   b. Test with sample source device with quantity of HDCP keys as required to operate by the system.

3.03 ACCEPTANCE TESTS

A. Acceptance Test: Owner’s Representative and/or Construction Manager will be present during acceptance testing and require assistance. Provide personnel who participated in the actual installation and preliminary testing and adjustment of the audiovisual systems. At their option, the Owner may contract and pay for a third-party consultant to perform system testing. This cost is not included in the Contractor’s contract.

Demonstrate each major component to function as specified.
B. Such tests may be performed on any piece of the system or individual equipment/device. If any test shows the equipment or system is defective or does not comply with the specifications, perform any remedies at your firm’s expense and pay the subsequent expenses of any required retesting.

3.04 TRAINING AND FIELD SUPPORT

C. Training: System Functionality
   a. Provide a minimum of one, eight-hour day of prepared and organized training sessions (separate from full dome training sessions) for the benefit of the Owner’s personnel. Demonstrate the location, wiring, operation and capabilities of each system component. Training time is to be non-contiguous, in multiple separate sessions.
   b. Develop with CCC, a training schedule to allow for training. Training shall be of sufficient duration and depth and the schedule shall allow adequate time for personnel to absorb the training.
   c. At minimum, include training on each component of the IPMS.

3.05 MISCELLANEOUS PROJECT REQUIREMENTS

A. Single Point of Contact: Provide an English-proficient, single point of contact, i.e., project manager, to speak for the Contractor and to provide the following functions:
   1. Initiate and coordinate tasks with Owner’s Project Manager, and others as specified by Owner’s Project Manager.
   2. Provide day-to-day direction and on-site supervision of Contractor personnel.
   3. Ensure conformance with all Contract provisions.
   4. Participate in weekly site project meetings as needed.
   5. This individual will remain as Project Manager for the duration of the project. The Contractor may change Project Managers only with the Owner’s Project Manager’s written approval.

B. Planning meetings and schedule: Within thirty (30) calendar days after the date of award of the Contract, an initial planning meeting will be held with the successful bidder to clarify all requirements (systems, services, distribution methods, etc.), identify responsibilities, and schedule the events that will transpire during the implementation of the project. Within one week of this initial meeting, the Contractor shall provide a written report and project schedule to clearly document the events and responsibilities associated with the project.

C. Site Cleaning: Throughout the progress of the plant construction, the Contractor shall keep the working area free from debris of all types and remove from the premises all rubbish resulting from any work done by Contractor. On a daily basis and at the completion of its work, the Contractor shall, to the extent possible, leave the premises in a clean and finished condition.

D. Safety Requirements: Contractor will utilize appropriate personnel and display warning signs, signals, flags and/or barricades at the work site to ensure adherence to safety regulations and as prudence requires.

E. Specification/Drawing Status: All specifications and drawings related to this project will be “frozen” after shop drawing approval. The Owner reserves the right to negotiate any future changes with the Contractor at any time.

F. Upon approval of shop drawings, contractor shall immediately place orders for all required materials, components, and supplies. In addition, contractor shall secure and forward written confirmations (including orders and shipping dates) direct from each manufacturer/vendor to the Owner’s Project Manager.
G. Contractor shall expedite shipment of all materials, components and supplies, as necessary to ensure the successful completion of the Project by the date required. All costs for expediting shall be included within contractor’s pricing as provided below.

H. The system cost herein shall include administration/maintenance training for at least ten Owner’s representatives with a minimum allotment of sixteen (16) hours. All training shall include written and/or video materials that shall remain the property of Owner. If materials are written, they shall be provided in quantities sufficient for each person trained; if materials are video, one copy of each will be required. The administration/maintenance training shall include, but not be limited to, the following:
   1. Review of as-built documentation, including a site demonstration.
   2. All warranty information.

3.06 DAMAGES

A. The Contractor will be held responsible for any and all damages to portions of the building caused by it, its employees or sub-contractors; including but not limited to:
   1. Damage to any portion of the building caused by the movement of tools, materials or equipment.
   2. Damage to any component of the construction of spaces.
   3. Damage to the electrical distribution system.
   4. Damage to the electrical, mechanical and/or life safety or other systems caused by inappropriate operation or connections made by the Contractor or other actions of Contractor.
   5. Damage to the materials, tools and/or equipment of the Owner, its consultants, agents and tenants.
   6. Damage to the projection dome surface
   7. Damage, interference, or outage to campus wide area or local area networks.

3.07 INSPECTIONS

A. On-going inspections shall be performed during construction by the Owner’s Project Manager. All work shall be performed in a high quality manner and the overall appearance shall be clean, neat and orderly. The following points will be examined and must be satisfactorily complied with:
   1. Are all cables properly labeled, from end-to-end?
   2. Have all terminated cables been properly tested in accordance with the specifications for the specific category as well as tested for opens, shorts, polarity reversals, transposition and presence of AC and/or DC voltage?
   3. Have the pathway guidelines been followed? Are all cable penetrations installed properly and fire stopped according to code?
   4. Has the Contractor avoided excessive cable bending?
   5. Is Cable fill correct?
   6. Are terminations compatible with applications equipment?
   7. Are connectors properly turned right side up in the Jack Panels or faceplates without cables wrapped or twisted?
   8. Is the jacket maintained right up to the termination?
   9. Are identification markings uniform, permanent and readable?

3.08 COMPLETION OF WORK

A. At the completion of the System, restore to its former condition, all aspects of the project site. On a daily basis, remove all waste and excess materials, rubbish debris, tools and equipment
resulting from or used in the services provided under this Contract. Provide all clean up, restoration, and removal noted above at no cost to Owner. If the Contractor fails in its duties under this paragraph, the Owner may upon notice to the Contractor perform the necessary clean up and deduct the costs thereof from any amounts due or to become due to the Contractor. Remove trash from work areas and bring it to the Contractor-provided dumpster.

B. Final Punch Walk: Complete a final inspection to determine if all conditions of the scope of work are completed to the owner’s satisfaction. Provide a punch list within ten days of the punch walk and present it to the Contractor for completion prior to final project sign-off by the owner. If an item is missed during the punch walk or not included on the “punch list” for any reason, it does not release the Contractor from completing the scope of work as defined in the specification or drawings.

C. Contractor shall submit complete Record Documentation as outlined in submittals section prior to project sign-off by owner.

3.09 SYSTEM AND/OR NETWORK TESTING

A. Upon completion of installation, execute all of the tests listed in this specification. Provide the Owner, written notice when all such tests have been completed to Owner’s satisfaction and Manufacturer’s specifications, Contractor shall give the Owner written notice thereof.

B. Assume responsibility of assuring that the system and network interface installed operates properly, including any required coordination with other suppliers.

3.10 FINAL ACCEPTANCE

A. The Owner or Owner's representative may visit the site during the installation of the system to ensure that correct installation practices are being followed.

B. Notify the Owner's representative when the systems are ready for a final job review. The review will take place within one week after notification.

C. If need for additional adjustment becomes evident during final acceptance and/or demonstration and testing, continue adjustment until the system functions fully as designed.

D. The Owner or Owner's representative will review the installation and certification data prior to the system acceptance.

E. The Owner or Owner's representative may test some of the system’s features to ensure that the certification data is correct. If a substantial discrepancy is found, the Owner reserves the right to have an independent consultant perform a certification of the entire system. If such a procedure is undertaken, the cost of the testing will be billed back to the Contractor.

F. In the event that repairs or adjustments are necessary, make these repairs at your firm’s expense. Complete all repairs within five days from the time they are disclosed to your firm.
SECTION 140413 - COMMON SUBMITTAL REQUIREMENTS FOR CONVEYING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
   1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering

1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 142123.16 - MACHINE-ROOM-LESS ELECTRIC TRACTION ELEVATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary
Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes machine-room-less electric traction passenger and elevators.

B. Related Requirements:
   1. Section 033000 "Cast-in-Place Concrete" for setting sleeves, inserts, and anchoring devices in concrete.
   2. Section 051200 "Structural Steel Framing" for the following:
      a. Attachment plates, angle brackets, and other preparation of structural steel for fastening guide-rail brackets.
   3. Section 055000 "Metal Fabrications" for the following:
      a. Hoist beams.
      b. Structural-steel shapes for subsills.
      c. Pit ladders.
      d. Cants made from steel sheet in hoistways.
   4. Division 09 Section for resilient flooring.
   5. Division 27 section for "Communications Horizontal Cabling" for telephone service for elevators.
   6. Division 28 Section for "Fire-Alarm System" for smoke detectors in elevator lobbies to initiate emergency recall operation, for heat detectors in shafts and machine rooms to disconnect power from elevator equipment before or on sprinkler activation, and for connection to elevator controllers.

1.3 DEFINITIONS

A. Definitions in ASME A17.1 apply to work of this Section.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include capacities, sizes, performances, operations, safety features, finishes, and similar information.
   2. Include Product Data for car enclosures, hoistway entrances, and operation, control, and signal systems.

B. Sustainable Design Submittals required by Section 01813 applicable to this Section.

C. Shop Drawings:
1. Include plans, elevations, sections, and large-scale details indicating service at each landing, coordination with building structure, relationships with other construction, and locations of equipment.

2. Include large-scale layout of car-control station and standby power operation control panel.

3. Indicate maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.

D. Samples for Verification: For exposed car, hoistway door and frame, and signal equipment finishes; 3-inch-square Samples of sheet materials; and 4-inch lengths of running trim members.

E. Delegated-Design Submittal: For installed products indicated to comply with performance requirements and design criteria, including comprehensive engineering analysis signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For elevators to include in emergency, operation, and maintenance manuals.

1. Submit manufacturer's or Installer's standard operation and maintenance manual, according to ASME A17.1 including diagnostic and repair information available to manufacturer's and Installer's maintenance personnel.

B. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.

C. Continuing Maintenance Proposal: Submit a continuing maintenance proposal from Installer to District, in the form of a standard two-year maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

D. Continuing Maintenance Proposal: Submit a continuing maintenance proposal from Installer to OwnerDistrict with terms, conditions, and obligations as set forth in, and in same form as, a "Draft of Elevator Maintenance Agreement" at end of this Section, starting on date initial maintenance service is concluded.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Elevator manufacturer or an authorized representative who is trained and approved by manufacturer.

B. Provide the following upon request:

1. Qualification Data: For Installer and structural engineer.

2. Seismic Qualification Certificates: For elevator equipment, accessories, and components, from manufacturer.

   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
3. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway and pit layout and dimensions, as indicated on Drawings, and electrical service including standby power generator, as shown and specified, are adequate for elevator system being provided.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle materials, components, and equipment in manufacturer's protective packaging. Store materials, components, and equipment off of ground, under cover, and in a dry location.

1.8 COORDINATION

A. Coordinate installation of inserts, sleeves, block outs, elevator equipment with integral anchors, and other items that are embedded in concrete or masonry for elevator equipment. Furnish templates, inserts, sleeves, elevator equipment with integral anchors, and installation instructions and deliver to Project site in time for installation.

B. Coordinate locations and dimensions of work specified in other Sections that relates to electric traction elevators including pit ladders; sumps and floor drains in pits; entrance subsills; electrical service; and electrical outlets, lights, and switches in hoistways and pits.

1.9 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair, restore, or replace elevator work that fails in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.

2. Warranty Period: 5 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Gen2 Machine-Room-Less Electric Underslung Traction elevator as manufactured by Otis Elevator Co., or comparable product by one of the following:

1. KONE Inc.
2. ThyssenKrupp Elevator.

B. Source Limitations: Obtain elevators from single manufacturer.

1. Major elevator components, including driving machines, controllers, signal fixtures, door operators, car frames, cars, and entrances, shall be manufactured by single manufacturer.
2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design products indicated, including, but limited to:
   1. Hoist beams.
   2. Guide rails and attachments to structure.

B. Regulatory Requirements: Comply with ASME A17.1.

C. Accessibility Requirements: Comply with requirements for accessible elevators in the United States Access Board's ADA-ABA Accessibility Guidelines and with ICC A117.1.

D. Seismic Performance: Elevator system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 Insert requirement and shall comply with elevator seismic requirements in ASME A17.1.
   1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
   2. Project Seismic Design Category: As indicated in Drawings.
   3. Elevator Component Importance Factor: 1.5 1.0.
   4. Provide earthquake equipment required by ASME A17.1.
   5. Provide seismic switch required by ASCE/SEI7.

E. Speed and Capacity:
   1. Car Speed: +/- 3 percent of contract speed under any loading condition or direction of travel.
   2. Car Capacity: Safely lower, stop and hold up to 120 percent of rated load.

F. Ride Quality:
   1. Vertical Vibration (maximum): 20 milli-g
   2. Horizontal Vibration (maximum): 12 milli-g
   3. Vertical Jerk (maximum): 4.59 +/- 1.0 ft./sec^3 (1.4 +/- 0.3 m/ sec^3)
   4. Acceleration/Deceleration (maximum): 2.62 ft./sec^2 (0.8 m/ sec^2)
   5. In Car Noise: 55 - 60 dB(A)
   6. Stopping Accuracy: +/- 0.375 inch (+/- 10 mm) maximum, +/- 0.25 inch (+/- 6 mm) typical.
   7. Re-leveling Distance: +/- 0.5 inch (+/- 12 mm)

2.3 ELEVATORS

A. Elevator System, General: Manufacturer's standard elevator systems. Unless otherwise indicated, manufacturer's standard components shall be used, as included in standard elevator systems and as required for complete system.

B. Elevator Description: Passenger Service
   1. Rated Load: 5000 lb.
   2. Rated Speed: 350 fpm.
   3. Number of Stops: 4
   4. Auxiliary Operations:
      a. Battery-powered automatic lowering.
c. Automatic dispatching of loaded car.
d. Off-peak operation.
e. Automatic operation of lights and ventilation fans.

5. Car Enclosures:
   a. Inside Cab Height: 117 inches.
   b. Inside Ceiling Height: 193 inches. Insert dimension 08 inches to underside of ceiling.
   c. Front Walls (Return Panels): Satin stainless steel, No. 4 finish.
   d. Car Fixtures: Satin stainless steel, No. 4 finish.
   e. Side and Rear Wall Panels: Satin stainless steel, No. 4 finish.
   f. Door Faces (Interior): Satin stainless steel, No. 4 finish.
   g. Door Sills: Aluminum.
   h. Ceiling: Stainless steel, perimeter-lit LED.
   i. Handrails: Rectangular flat baluster dimension r, satin stainless steel at sides and rear of car.
   j. Floor prepared to receive resilient flooring (specified in Section 096516 "Resilient Sheet Flooring").
   k. Car Operating Panel: Swing return.

6. Hoistway Entrances:
   a. Width: 36 inches 42 inches 48 inches 54 inches Insert dimension.
   b. Height: 84 inches 96 inches.
   c. Type: Two-speed center opening.
   d. Frames: Satin stainless steel, No. 4 finish.
   e. Doors: Satin stainless steel, No. 4 finish.
   f. Sills: Aluminum.


   a. Hall Buttons: Lobby (First Floor), Intermediate, and Terminal (Roof).

10. Additional Requirements:
    a. Provide inspection certificate in each car, mounted under acrylic cover with frame made from polished stainless steel, No. 8 finish.
    b. Provide hooks for protective pads in all cars and one complete set(s) of full-height protective pads.

11. Main Power Supply: 480 Volts, +/- 5 percent of normal, Three-phase, with a separate equipment grounding conductor.


13. Machine Location: Inside the hoistway at the top of the hoistway.

14. Controller Location: Machine-Roomless Controller(s) shall be located at the front opening of the top terminal landing in entrance frame.

2.4 TRACTION SYSTEMS

A. Elevator Machines: Permanent magnet, variable-voltage, variable-frequency, ac-type hoisting machines and solid-state power converters.

1. Provide regenerative system that complies with the IgCC.
2. Limit total harmonic distortion of regenerated power to 5 percent per IEEE 519.
3. Provide means for absorbing regenerated power when elevator system is operating on standby power.
4. Provide line filters or chokes to prevent electrical peaks or spikes from feeding back into building power system.

B. Fluid for Hydraulic Buffers: Fire-resistant fluid.

C. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work. Device installation is specified in another Section.

D. Machine Beams: Provide steel framing to support elevator hoisting machine and deflector sheaves from the building structure. Comply with Section 055000 "Metal Fabrications" for materials and fabrication.

E. Car Frame and Platform: Bolted- or welded-steel units.

F. Guides: Roller guides or polymer-coated, nonlubricated sliding guides. Provide guides at top and bottom of car and counterweight frames.

2.5 OPERATION SYSTEMS

A. General: Provide manufacturer's standard microprocessor operation systems as required to provide type of operation indicated.

B. Auxiliary Operations:
   1. Single-Car Battery-Powered Automatic Lowering: If power fails and car is at a floor, elevator shall remain at that floor, open doors, and shut down. If car is between floors, elevator shall move to lower floor, open doors, and shut down. System shall include rechargeable battery and automatic recharging system.
   2. Automatic Operation of Lights and Fan: When elevator is stopped and unoccupied with doors closed, lighting, ventilation fan, and cab displays are de-energized after five minutes and are re-energized before car doors open.

2.6 DOOR REOPENING DEVICES

A. Infrared Array: Provide door reopening device with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more light beams shall cause doors to stop and reopen.

2.7 CAR ENCLOSURES

A. General: Provide enameled or powder-coated steel car enclosures to receive removable steel-framed car enclosures with nonremovable wall panels, with removable car roof, access doors, power door operators, and ventilation.
   1. Provide standard railings complying with ASME A17.1 on car tops where required by ASME A17.1.

B. Materials and Finishes: Manufacturer's standards, but not less than the following:
   1. Subfloor: Exterior, C-C Plugged grade plywood, not less than 7/8-inch nominal thickness.
   2. Stainless-Steel Wall Panels: Flush, formed-metal construction; fabricated from stainless-steel sheet.
   3. Fabricate car with recesses and cutouts for signal equipment.
4. Fabricate car door frame integrally with front wall of car.
5. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled or powder-coated steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
6. Sills: Extruded or machined metal, with grooved surface, 1/4 inch thick.
7. Light Fixture Efficiency: Not less than 35 lumens/W.
8. Ventilation Fan Efficiency: Not less than 3.0 cfm/W.

2.8 HOISTWAY ENTRANCES

A. Hoistway Entrance Assemblies: Manufacturer's standard horizontal-sliding, door-and-frame hoistway entrances complete with track systems, hardware, sills, and accessories. Frame size and profile shall accommodate hoistway wall construction.
   1. Where gypsum board wall construction is indicated, frames shall be self-supporting with reinforced head sections.

B. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies shall comply with NFPA 80 and be listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction based on testing at as close-to-neutral pressure as possible according to or .
   1. Fire-Protection Rating: As indicated1 hour 1-1/2 hours Insert rating with 30-minute temperature rise of 450 deg F.

C. Materials and Fabrication: Manufacturer's standards, but not less than the following:
   2. Star of Life Symbol: Identify emergency elevators with star of life symbol, not less than 3 inches high, on both jambs of hoistway door frames.
   3. Stainless-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled or powder-coated steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
   4. Sills: Extruded or machined metal, with grooved surface, 1/4 inch thick.

2.9 SIGNAL EQUIPMENT

A. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Provide vandal-resistant buttons and lighted elements illuminated with LEDs.

B. Car-Control Stations: Provide manufacturer's standard recessed car-control stations. Mount in return panel adjacent to car door unless otherwise indicated.
   1. Mark buttons and switches for required use or function. Use both tactile symbols and Braille.
   2. Provide "No Smoking" sign matching car-control station, either integral with car-control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.

C. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet telephone jack in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Division 28 Section for "Fire-Alarm System."
D. Car Position Indicator: Provide illuminated, digital-type car position indicator, located above car door or above car-control station. Also, provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served. Include travel direction arrows if not provided in car-control station.

E. Hall Push-Button Stations: Provide one hall push-button station at each landing.
   1. Provide units with flat faceplate for mounting with body of unit recessed in wall.
   2. Equip units with buttons for calling elevator and for indicating desired direction of travel.
      a. Provide for connecting units to building security access system so a card reader can be used to register calls.
   3. Provide telephone jack in each unit for firefighters' two-way telephone communication service specified in Division 28 Section for "Fire-Alarm System."

F. Hall Lanterns: Units with illuminated arrows; but provide single arrow at terminal landings. Provide one of the following:
   1. Units with flat faceplate for mounting with body of unit recessed in wall and with illuminated elements projecting from faceplate for ease of angular viewing.

G. Hall Annunciator: With each hall lantern, provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.
   1. At manufacturer's option, audible signals may be placed on cars.

H. Fire-Command-Center Annunciator Panel: Provide panel containing illuminated position indicators for each elevator, clearly labeled with elevator designation; include illuminated signal that indicates when elevator is operational and when it is at the designated emergency return level with doors open. Provide standby power elevator selector switch(es), as required by ASME A17.1, adjacent to position indicators. Provide illuminated signal that indicates when normal power supply has failed.

I. Emergency Pictorial Signs: Fabricate from materials matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire, elevators are out of service and exits should be used instead. Provide one sign at each hall push-button station unless otherwise indicated.

2.10 FINISH MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A 1008, commercial steel, Type B, exposed, matte finish.

B. Hot-Rolled Steel Sheet: ASTM A 1011, commercial steel, Type B, pickled.

C. Stainless-Steel Sheet: ASTM A 240, Type 304.

D. Stainless-Steel Bars: ASTM A 276, Type 304.

E. Stainless-Steel Tubing: ASTM A 554, Grade MT 304.

F. Aluminum Extrusions: ASTM B 221, Alloy 6063.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elevator areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work. Examine hoistways, hoistway openings, and pits as constructed; verify critical dimensions; and examine supporting structure and other conditions under which elevator work is to be installed.

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's written instructions.

B. Welded Construction: Provide welded connections for installing elevator work where bolted connections are not required for subsequent removal or for normal operation, adjustment, inspection, maintenance, and replacement of worn parts. Comply with AWS standards for workmanship and for qualifications of welding operators.

C. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts to minimize vibration transmission to structure and structure-borne noise due to elevator system.

D. Lubricate operating parts of systems, including ropes, as recommended by manufacturers.

E. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Where possible, delay final adjustment of sills and doors until car is operable in shaft. Reduce clearances to minimum, safe, workable dimension at each landing.

F. Leveling Tolerance: 1/8 inch, up or down, regardless of load and travel direction.

G. Set sills flush with finished floor surface at landing. Fill space under sill solidly with nonshrink, nonmetallic grout.

H. Locate hall signal equipment for elevators as follows unless otherwise indicated:
   1. Place hall lanterns either above or beside each hoistway entrance.
   2. Mount hall lanterns at a minimum of 72 inches above finished floor.

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of elevator installation and before permitting elevator use (either temporary or permanent), perform acceptance tests as required and recommended by ASME A17.1 and by governing regulations and agencies.

B. Operating Test: Load elevator to rated capacity and operate continuously for 30 minutes over full travel distance, stopping at each level and proceeding immediately to the next. Record temperature rise of elevator machine during 30-minute test period. Record failure to perform as required.
C. Advise District, Architect, and authorities having jurisdiction in advance of dates and times that tests are to be performed on elevators.

3.4 PROTECTION

A. Temporary Use: Comply with the following requirements for elevator used for construction purposes:
   1. Provide car with temporary enclosure, either within finished car or in place of finished car, to protect finishes from damage.
   2. Provide strippable protective film on entrance and car doors and frames.
   3. Provide padded wood bumpers on entrance door frames covering jambs and frame faces.
   4. Provide other protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.
   5. Do not load elevators beyond their rated weight capacity.
   6. Engage elevator Installer to provide full maintenance service. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleanup, and adjustment as necessary for proper elevator operation at rated speed and capacity. Provide parts and supplies same as those used in the manufacture and installation of original equipment.
   7. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train District's maintenance personnel to operate, adjust, and maintain elevator.

B. Check operation of elevator with District's personnel present before date of Substantial Completion and again not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

3.6 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 24 months' full maintenance by skilled employees of elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation at rated speed and capacity. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
   1. Perform maintenance during normal working hours.
   2. Perform emergency callback service during normal working hours with response time of two hours or less.
   3. Include 24-hour-per-day, 7-day-per-week emergency callback service with response time of two hours or less.

END OF SECTION
C-4016 New Science Building – Increment 2

At

Contra Costa College
2600 Mission Bell Dr., San Pablo, CA 94806

CONTRA COSTA COMMUNITY COLLEGE DISTRICT

Consists of:

VOLUME 3 - Division 21 - 33

DSA File #7-C1
DSA Appl. #01-117149

Architect:

SmithGroup, Inc.
301 Battery Street, 7th Floor
San Francisco, CA 94111
415.227.0100

July 24, 2019
ARCHITECT: SMITHGROUP
Chun-Kei J. Wong
301 Battery Street, 7th Floor
San Francisco, Ca 94111
(415) 227-0100

LANDSCAPE ARCHITECT: RHAA
Manuela King
225 Miller Ave.
Mill Valley, CA 94941
(415) 383-7900

CIVIL ENGINEER: BKF ENGINEERS
Dayne Johnson
1646 N. California Blvd, #400,
Walnut Creek, CA 94596
(925) 940-2200

LABORATORY PLANNING: RESEARCH FACILITIES DESIGN
Richard M. Heinz
3965 Fifth Avenue, Suite 400
San Diego, CA 92103
(619) 297-0159

STRUCTURAL ENGINEER: RUTHERFORD + CHEKENE
David Bleiman
375 Beale Street, Suite 310
San Francisco, CA 94105
(415) 568-4400
MECHANICAL ENGINEER
INTEGRAL GROUP
David Costello
427 13th Street
Oakland, CA 94611
(510) 663-2070

ELECTRICAL ENGINEER
INTEGRAL GROUP
Vish Mahajan
427 13th Street
Oakland, CA 94611
(510) 663-2070

FIRE PROTECTION ENGINEER
THE FIRE CONSULTANTS, INC.
John Stauder
1777 N. California Blvd., Suite 200
Walnut Creek, CA 94596
(925) 979-9993

TECHNOLOGY ENGINEER
TEECOM
Larry A. Anderson
1333 Broadway Suite 601
Oakland, CA 94612-1906
(510) 337-2800

END OF SECTION 00007
SECTION 00010

TABLE OF CONTENTS

VOLUME 1 – DIVISIONS 00 - 01

DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS
SECTION 00001 TITLE PAGE
SECTION 00007 SEALS PAGE
SECTION 00010 TABLE OF CONTENTS
SECTION 00016 CCC COLLEGE COMPLEX MAP (Note Location for Pre-Bid Meeting)
SECTION 00100 NOTICE INVITING BIDS
SECTION 00200 INSTRUCTIONS TO BIDDERS
SECTION 00210 INFORMATION AVAILABLE TO BIDDERS
SECTION 00300 BID PROPOSAL FORM
SECTION 00350 NON-COLLUSION AFFIDAVIT
SECTION 00400 STATEMENT OF BIDDER’S QUALIFICATIONS
SECTION 00450 CERTIFICATION OF SITE VISIT
SECTION 00500 PAYMENT AND PERFORMANCE BOND
SECTION 00510 NOTICE OF AWARD
SECTION 00600 CONSTRUCTION AGREEMENT
SECTION 00650 NOTICE TO PROCEED
SECTION 00700 GENERAL CONDITIONS

DIVISION 01 - GENERAL REQUIREMENTS
SECTION 01010 SUMMARY OF WORK
SECTION 01015 ADDITIONAL REQUIREMENTS FOR DSA-APPROVED PROJECTS
SECTION 01030 ALTERNATES
SECTION 01050 FIELD ENGINEERING
SECTION 01055 CONFORMANCE SURVEYING
SECTION 01140 WORK RESTRICTIONS
SECTION 01250 CONTRACT MODIFICATION PROCEDURES
SECTION 01290 PAYMENT PROCEDURES
SECTION 01300 LABOR COMPLIANCE PROGRAM
SECTION 01305 DELAY AND EXTENSIONS TO THE WORK
SECTION 01310 CONSTRUCTION SCHEDULING
SECTION 01311 PROJECT MANAGEMENT AND COORDINATION
SECTION 01312 PROJECT MEETINGS
SECTION 01316 BUILDING INFORMATION MODELING (BIM)
SECTION 01318 DOCUMENT MANAGEMENT SYSTEM
SECTION 01321 PHOTOGRAPHIC DOCUMENTATION
SECTION 01330 SUBMITTAL PROCEDURES
SECTION 01340 ADMINISTRATIVE FORMS AND LOGS
SECTION 01400 QUALITY CONTROL REQUIREMENTS
SECTION 01405 MOCKUP REQUIREMENTS, Provided by SmithGroup
SECTION 01410 REGULATORY REQUIREMENTS
SECTION 01411 TESTING LABORATORY SERVICES
SECTION 01412 HAZARDOUS MATERIALS
SECTION 01414 GUIDELINES FOR OPERATIONS DURING A PROTEST
SECTION 01415 MITIGATION MONITORING REGULATORY REQUIREMENTS
SECTION 01416 SPECIAL PROCEDURES
SECTION 01420 REFERENCES
SECTION 01500 TEMPORARY FACILITIES AND CONTROL
SECTION 01505 CONSTRUCTION WASTE MANAGEMENT
SECTION 01540 SITE SECURITY AND SAFETY
SECTION 01572 STORM WATER POLLUTION PREVENTION
SECTION 01610 BASIC PRODUCT REQUIREMENTS
SECTION 01625 PRODUCT OPTIONS AND SUBSTITUTIONS
SECTION 01710 CLEANING REQUIREMENTS
SECTION 01722 EXECUTION REQUIREMENTS
SECTION 01730 CUTTING AND PATCHING
SECTION 01740 WARRANTIES / GUARANTIES
SECTION 01770 CONTRACT CLOSEOUT PROCEDURES
SECTION 01780 PROJECT RECORD DOCUMENTS
SECTION 01785 OPERATIONS AND MAINTENANCE DATA
SECTION 01805 CALGREEN ENVIRONMENTAL REQUIREMENTS, Provided by SmithGroup
SECTION 01813 SUSTAINABLE DESIGN REQUIREMENTS, Provided by SmithGroup
SECTION 01820 DEMONSTRATION AND TRAINING
SECTION 01913 GENERAL COMMISSIONING REQUIREMENTS, Provided by Enovity

VOLUME 2 – TECHNICAL SPECIFICATIONS - DIVISION 02 - 14, Provided by SmithGroup

DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS
SECTION 00001 TITLE PAGE
SECTION 00007 SEALS PAGE
SECTION 00010 TABLE OF CONTENTS

DIVISION 02 - EXISTING CONDITIONS
SECTION 024113 SELECTIVE SITE DEMOLITION

DIVISION 03 - CONCRETE
SECTION 030413 COMMON SUBMITTAL REQUIREMENTS FOR CONCRETE
SECTION 031100 CONCRETE FORMING
SECTION 031500 CONCRETE ACCESSORIES
SECTION 032000 CONCRETE REINFORCING
SECTION 033000 CAST-IN-PLACE CONCRETE
SECTION 033543 POLISHED CONCRETE FINISHING
SECTION 033546 SEALED CONCRETE FINISHING
SECTION 036100 GROUTED DOWELS IN CONCRETE

DIVISION 04 - MASONRY
SECTION 040413 COMMON SUBMITTAL REQUIREMENTS FOR MASONRY
SECTION 042113 BRICK MASONRY

DIVISION 05 - METALS
SECTION 050413 COMMON SUBMITTAL REQUIREMENTS FOR METALS
SECTION 050525 POST-INSTALLED CONCRETE ANCHORS
SECTION 051200 STRUCTURAL STEEL FRAMING
SECTION 051213 ARCHITECTURALLY EXPOSED STRUCTURAL STEEL (AESS)
SECTION 051250 BUCKLING RESTRAINED BRACES
SECTION 053100 STEEL DECKING
SECTION 054000 COLD-FORMED METAL FRAMING
SECTION 055000 METAL FABRICATIONS
SECTION 055113 METAL PAN STAIRS
SECTION 055119 METAL GRATING STAIRS
SECTION 055213 PIPE AND TUBE RAILINGS
SECTION 057005 LANDSCAPE METALWORK
SECTION 057100 DECORATIVE METAL STAIRS
SECTION 057300 DECORATIVE METAL RAILINGS
DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES
SECTION 060413 COMMON SUBMITTAL REQUIREMENTS FOR WOODS, PLASTICS, AND COMPOSITES
SECTION 061000 ROUGH CARPENTRY
SECTION 061600 SHEATHING
SECTION 064116 PLASTIC-LAMINATE-FACED ARCHITECTURAL CABINETS
SECTION 066400 PLASTIC PANELING

DIVISION 07 - THERMAL AND MOISTURE PROTECTION
SECTION 070413 COMMON SUBMITTAL REQUIREMENTS FOR THERMAL AND MOISTURE PROTECTION
SECTION 071113 BITUMINOUS DAMPPROOFING
SECTION 071326 BELOW-GRADE SHEET WATERPROOFING
SECTION 071413 HOT FLUID-APPLIED RUBBERIZED ASPHALT WATERPROOFING
SECTION 071619 METAL OXIDE WATERPROOFING
SECTION 072100 THERMAL INSULATION
SECTION 072726 MEMBRANE AIR BARRIERS
SECTION 074213 METAL WALL PANELS
SECTION 075419 POLYVINYL-CHLORIDE (PVC) ROOFING
SECTION 075556 FLUID-APPLIED PROTECTED MEMBRANE ROOFING
SECTION 076200 SHEET METAL FLASHING AND TRIM
SECTION 077200 ROOF ACCESSORIES
SECTION 078413 PENETRATION FIRESTOPPING
SECTION 079200 JOINT SEALANTS
SECTION 079513.16 EXTERIOR EXPANSION JOINT COVER ASSEMBLIES

DIVISION 08 - OPENINGS
SECTION 080413 COMMON SUBMITTAL REQUIREMENTS FOR OPENINGS
SECTION 081113 HOLLOW METAL DOORS AND FRAMES
SECTION 081416 FLUSH WOOD DOORS
SECTION 083113 ACCESS DOORS AND FRAMES
SECTION 083473.13 METAL SOUND CONTROL DOOR ASSEMBLIES
SECTION 084113 ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS
SECTION 084216 INTERIOR ALUMINUM STOREFRONT FRAMES
SECTION 08429.23 SLIDING AUTOMATIC ENTRANCES
SECTION 084413 GLAZED ALUMINUM CURTAIN WALLS
SECTION 084423 STRUCTURAL-SEALANT-GLAZED CURTAIN WALLS
SECTION 085113 MISCELLANEOUS INTERIOR ALUMINUM WINDOWS
SECTION 087100 DOOR HARDWARE
SECTION 087113 AUTOMATIC DOOR OPERATORS
SECTION 088000 GLAZING
SECTION 088300 MIRRORS
SECTION 088813 FIRE-RESISTANT GLAZING AND FRAMING
SECTION 089119 FIXED LOUVERS

DIVISION 09 - FINISHES
SECTION 090413 COMMON SUBMITTAL REQUIREMENTS FOR FINISHES
SECTION 090561.13 MOISTURE VAPOR EMISSION CONTROL
SECTION 092116.23 GYPSUM BOARD SHAFT WALL ASSEMBLIES
SECTION 092216 NON-STRUCTURAL METAL FRAMING
SECTION 092400 CEMENT PLASTERING
SECTION 092900 GYPSUM BOARD
SECTION 093013 TILING
SECTION 095113 SUSPENDED ACOUSTICAL CEILINGS
SECTION 095423  SUSPENDED METAL CEILINGS
SECTION 096513  RESILIENT BASE AND ACCESSORIES
SECTION 096516  RESILIENT SHEET FLOORING
SECTION 096519  RESILIENT TILE FLOORING
SECTION 096723  RESINOUS FLOORING AND WALL COATINGS
SECTION 096813  TILE CARPETING
SECTION 097200  WALL COVERINGS
SECTION 098100  ACOUSTICAL INSULATION
SECTION 099600  HIGH-PERFORMANCE COATINGS

DIVISION 10 - SPECIALTIES
SECTION 100413  COMMON SUBMITTAL REQUIREMENTS FOR SPECIALTIES
SECTION 101100  VISUAL DISPLAY UNITS
SECTION 101200  DISPLAY CASES
SECTION 101419  DIMENSIONAL LETTER SIGNAGE
SECTION 101423  SIGNAGE
SECTION 102113.17  PHENOLIC-CORE TOILET COMPARTMENTS
SECTION 102600  WALL AND DOOR PROTECTION
SECTION 102800  TOILET, BATH AND MISCELLANEOUS ACCESSORIES
SECTION 104413  FIRE PROTECTION CABINETS
SECTION 104416  FIRE EXTINGUISHERS

DIVISION 11 - EQUIPMENT
SECTION 110413  COMMON SUBMITTAL REQUIREMENTS FOR EQUIPMENT
SECTION 113100  RESIDENTIAL APPLIANCES
SECTION 115310  LABORATORY CASework AND OTHER FURNISHINGS
SECTION 115313  Fume HOODs AND OTHER AIR CONTAINMENT UNITS
SECTION 115343  LABORATORY SERVICE FITTINGS AND FIXTURES
SECTION 115350  LABORATORY EQUIPMENT

DIVISION 12 - FURNISHINGS
SECTION 120413  COMMON SUBMITTAL REQUIREMENTS FOR FURNISHINGS
SECTION 122413  ROLLER WINDOW SHADES
SECTION 123661.16  SOLID SURFACING COUNTERTOPS
SECTION 124813  ENTRANCE FLOOR MATS
SECTION 126100  FIXED AUDIENCE SEATING

DIVISION 13 - SPECIAL CONSTRUCTION
SECTION 130413  COMMON SUBMITTAL REQUIREMENTS FOR SPECIAL CONSTRUCTION
SECTION 132300  PLANETARIUM DOME
SECTION 132310  PLANETARIUM PROJECTION SYSTEM

DIVISION 14 - CONVEYING EQUIPMENT
SECTION 140413  COMMON SUBMITTAL REQUIREMENTS FOR CONVEYING EQUIPMENT
SECTION 142123.16  MACHINE-ROOM-LESS ELECTRIC TRACTION ELEVATORS

VOLUME 3 – TECHNICAL SPECIFICATIONS - DIVISION 21 – 33, Provided by SmithGroup
DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS
SECTION 00001  TITLE PAGE
SECTION 00007  SEALS PAGE
# Contra Costa Community College District
## Contra Costa College
### C-4016 New Science Building – Increment 2

## DSA Appl. #01-117149

## Table of Contents

### DIVISION 21 - FIRE SUPPRESSION
- SECTION 210413 COMMON SUBMITTAL REQUIREMENTS FOR FIRE SUPPRESSION
- SECTION 211313 WET-PIPE SPRINKLER SYSTEM

### DIVISION 22 - PLUMBING
- SECTION 220000 PLUMBING GENERAL REQUIREMENTS
- SECTION 220413 COMMON SUBMITTAL REQUIREMENTS FOR PLUMBING
- SECTION 220513 COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT
- SECTION 220517 SLEEVES AND SLEEVE SEALS FOR PLUMBING
- SECTION 220518 ESCUTCHEONS FOR PLUMBING PIPING
- SECTION 220519 METERS AND GAUGES FOR PLUMBING PIPING
- SECTION 220523 GENERAL DUTY VALVES FOR PLUMBING PIPING
- SECTION 220529 HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
- SECTION 220548 VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT
- SECTION 220553 IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
- SECTION 220716 PLUMBING EQUIPMENT INSULATION
- SECTION 220719 PLUMBING PIPING INSULATION
- SECTION 220800 COMMISSIONING OF PLUMBING SYSTEMS
- SECTION 221116 DOMESTIC WATER PIPING
- SECTION 221118 NATURAL-GAS PIPING
- SECTION 221119 DOMESTIC WATER PIPING SPECIALTIES
- SECTION 221123.13 DOMESTIC-WATER PACKAGED BOOSTER PUMPS
- SECTION 221316 SANITARY WASTE AND VENT PIPING
- SECTION 221319 SANITARY WASTE PIPING SPECIALTIES
- SECTION 221319.13 SANITARY DRAINS
- SECTION 221413 STORM DRAINAGE PIPING
- SECTION 221423 STORM DRAINAGE PIPING SPECIALTIES
- SECTION 223000 PLUMBING EQUIPMENT
- SECTION 223600 REVERSE OSMOSIS WATER EQUIPMENT
- SECTION 224200 PLUMBING FIXTURES
- SECTION 224500 EMERGENCY PLUMBING FIXTURES
- SECTION 225213 VACUUM PIPING FOR LABORATORY FACILITIES
- SECTION 225219 VACUUM EQUIPMENT FOR LABORATORY FACILITIES
- SECTION 226600 LABORATORY WASTE SYSTEMS FOR LABORATORY FACILITIES
- SECTION 226700 PROCESSED WATER SYSTEMS FOR LABORATORY FACILITIES

### DIVISION 23 - HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)
- SECTION 230000 HVAC GENERAL REQUIREMENTS
- SECTION 230413 COMMON SUBMITTAL REQUIREMENTS FOR HVAC
- SECTION 230513 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
- SECTION 230514 VARIABLE-FREQUENCY DRIVES FOR HVAC EQUIPMENT
- SECTION 230516 EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING
- SECTION 230519 METERS AND GAUGES FOR HVAC PIPING
- SECTION 230523 VALVES FOR HVAC PIPING
- SECTION 230529 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
- SECTION 230548 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
- SECTION 230553 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
- SECTION 230593 TESTING, ADJUSTING, AND BALANCING FOR HVAC
- SECTION 230713 HVAC DUCT INSULATION
- SECTION 230716 HVAC PIPING AND EQUIPMENT INSULATION
- SECTION 230800 COMMISSIONING OF MECHANICAL SYSTEMS
- SECTION 232113 HYDRONIC PIPING
| SECTION 232116 | HYDRONIC PIPING SPECIALTIES |
|SECTION 232123 | HYDRONIC PUMPS |
|SECTION 232500 | HVAC WATER TREATMENT |
|SECTION 233100 | HVAC METAL DUCTS |
|SECTION 233300 | HVAC DUCT ACCESSORIES |
|SECTION 233400 | HVAC FANS |
|SECTION 233600 | AIR TERMINAL UNITS |
|SECTION 233700 | AIR OUTLETS AND INLETS |
|SECTION 237300 | CUSTOM AIR HANDLING UNITS |
|SECTION 238143 | AIR-SOURCE UNITARY HEAT PUMPS |
|SECTION 238219 | FAN COIL UNITS |

**DIVISION 25 - INTEGRATED AUTOMATION**

- SECTION 250000 BUILDING AUTOMATION SYSTEMS
- SECTION 250413 COMMON SUBMITTAL REQUIREMENTS FOR INTEGRATED AUTOMATION
- SECTION 253000 BUILDING AUTOMATION SENSORS AND CONTROL DEVICES
- SECTION 255005 LABORATORY MONITORING AND CONTROL SYSTEM
- SECTION 259000 BUILDING AUTOMATION SEQUENCES OF OPERATIONS

**DIVISION 26 - ELECTRICAL**

- SECTION 260413 COMMON SUBMITTAL REQUIREMENTS FOR ELECTRICAL
- SECTION 260513 MEDIUM-VOLTAGE CABLES
- SECTION 260519 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
- SECTION 260533 IDENTIFICATION FOR ELECTRICAL SYSTEMS
- SECTION 260913.01 ELECTRICAL POWER MONITORING AND CONTROL
- SECTION 261219 PAD MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS
- SECTION 262213 LOW-VOLTAGE DISTRIBUTION TRANSFORMERS
- SECTION 262413 SWITCHBOARDS
- SECTION 262813 FUSES
- SECTION 262816 ENCLOSED SWITCHES AND CIRCUIT BREAKERS
- SECTION 263213.13 DIESEL EMERGENCY ENGINE GENERATORS
- SECTION 263600 TRANSFER SWITCHES
- SECTION 264313 SURGE PROTECTION FOR LOW VOLTAGE ELECTRICAL POWER CIRCUITS
- SECTION 265119 LED INTERIOR LIGHTING
- SECTION 265613 LIGHTING POLES AND STANDARDS
- SECTION 265619 LED EXTERIOR LIGHTING
- SECTION 266315 PLANETARIUM LIGHTING TECHNOLOGY PACKAGE (PLTS)
DIVISION 27 - COMMUNICATIONS
SECTION 270000 BASIC COMMUNICATIONS REQUIREMENTS
SECTION 270413 COMMON SUBMITTAL REQUIREMENTS FOR COMMUNICATIONS
SECTION 270526 COMMUNICATIONS GROUNDING AND BONDING
SECTION 270528 COMMUNICATIONS BUILDING PATHWAYS
SECTION 270533 COMMUNICATIONS BUILDING PATHWAYS – CONDUITS AND BOXES
SECTION 270536 COMMUNICATIONS BUILDING PATHWAYS – CABLE TRAYS
SECTION 270811 COMMUNICATIONS TWISTED PAIR TESTING
SECTION 270821 COMMUNICATIONS FIBER OPTIC TESTING
SECTION 271100 COMMUNICATIONS EQUIPMENT ROOMS
SECTION 271313 COMMUNICATIONS BACKBONE ISP TWISTED PAIR CABLING
SECTION 271314 COMMUNICATIONS BACKBONE OSP TWISTED PAIR CABLING
SECTION 271323 COMMUNICATIONS BACKBONE ISP FIBER OPTIC CABLING
SECTION 271324 COMMUNICATIONS BACKBONE OSP FIBER OPTIC CABLING
SECTION 271513 COMMUNICATIONS HORIZONTAL TWISTED PAIR CABLING
SECTION 272310 INSTRUCTIONAL PLANETARIUM MEDIA SYSTEMS (IPMS)
SECTION 272315 PLANETARIUM SOUND SYSTEM (PSS)
SECTION 274113 ARCHITECTURALLY INTEGRATED PROJECTION SCREENS
SECTION 274116 INTEGRATED AUDIOVISUAL SYSTEMS

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY
SECTION 280000 BASIC SECURITY REQUIREMENTS
SECTION 280413 COMMON SUBMITTAL REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY
SECTION 280513 SECURITY SYSTEM CABLING
SECTION 280553 SECURITY SYSTEM LABELING
SECTION 280800 SECURITY SYSTEM ACCEPTANCE TESTING
SECTION 281300 ACCESS CONTROL AND ALARM MONITORING SYSTEM
SECTION 281600 INTRUSION DETECTION SYSTEM
SECTION 282300 VIDEO SURVEILLANCE SYSTEM
SECTION 283100 ANALOG ADDRESSABLE FIRE ALARM DETECTION SYSTEM

DIVISION 31 - EARTHWORK
SECTION 310413 COMMON SUBMITTAL REQUIREMENTS FOR EARTHWORK
SECTION 311001 PLANT PROTECTION
SECTION 311100 CLEARING & GRUBBING
SECTION 311200 SOIL STRIPPING & STOCKPILING
SECTION 312300 EXCAVATION AND FILL
SECTION 312305 STRUCTURAL EXCAVATION AND FILL
SECTION 312333 UTILITY TRENCHING AND BACKFILLING
SECTION 312500 EROSION AND SEDIMENTATION CONTROL
SECTION 315000 TEMPORARY EXCAVATION SUPPORT AND PROTECTION
SECTION 316800 FOUNDATION TIEDOWN ANCHORS

DIVISION 32 - EXTERIOR IMPROVEMENTS
SECTION 320413 COMMON SUBMITTAL REQUIREMENTS FOR EXTERIOR IMPROVEMENTS
SECTION 320523 PORTLAND CEMENT CONCRETE PAVING
SECTION 320800 COMMISSIONING OF IRRIGATION SYSTEMS
SECTION 321132 AGGREGATE BASE COURSE
SECTION 321312 SITE CONCRETE
SECTION 321616 ASPHALT CONCRETE PAVEMENT
SECTION 323300 SITE FURNISHINGS
SECTION 328400 IRRIGATION
SECTION 329000 PLANTING
SECTION 329451 MODULAR SUSPENDED PAVEMENT SYSTEM
DIVISION 33 - UTILITIES

SECTION 330413  COMMON SUBMITTAL REQUIREMENTS FOR UTILITIES
SECTION 331166  WATER DISTRIBUTION SYSTEM
SECTION 334100  STORM DRAINAGE SYSTEM

DRAWINGS – Provided by SmithGroup

GENERAL

G0.0  PROJECT COVER SHEET
G0.1  PROJECT SHEET INDEX
G0.2  GENERAL PROJECT INFORMATION
G0.3  BASIC ACCESSIBILITY REQUIREMENTS
G0.4  BASIC ACCESSIBILITY REQUIREMENTS
G0.5  TYPICAL TOILET ROOM MOUNTING HEIGHTS AND STALL CONFIGURATION DIAGRAMS
G0.6  TYPICAL MOUNTING HEIGHTS AND DIMENSIONING CONVENTIONS
G0.7  TYPICAL RULES FOR DETERMINING MOUNTING HEIGHTS AND LOCATIONS
G0.8  TYPICAL REFLECTED CEILING ITEMS LOCATIONS AND CONFIGURATIONS AND SPRINKLER HEAD TOLERANCES
G0.9  HAZARDOUS MATERIAL INVENTORY STATEMENT
G0.10 HAZARDOUS MATERIAL INVENTORY STATEMENT
G0.11 HAZARDOUS MATERIAL INVENTORY STATEMENT
G1.1  ACCESSIBILITY SITE PLAN
G2.2.1 FIRE AND LIFE SAFETY DRAWINGS LEVEL 1
G2.2.2 FIRE AND LIFE SAFETY DRAWINGS LEVEL 2
G2.2.3 FIRE AND LIFE SAFETY DRAWINGS LEVEL 3
G2.2.4 FIRE AND LIFE SAFETY DRAWINGS ROOF

CIVIL

C1.00.V2  EXISTING SITE PLAN
C1.01.V2  EXISTING UTILITY PLAN
C2.00.V2  DEMOLITION PLAN
C3.00.V2  HORIZONTAL CONTROL PLAN
C4.00.V2  GRADING PLAN
C5.00.V2  UTILITY PLAN
C6.00.V2  EROSION CONTROL PLAN
C7.00.V2  CONSTRUCTION DETAILS
C8.00.V2  FIRE ACCESS PLAN

LANDSCAPE

L0.00  COVER SHEET
L1.00  LAYOUT PLAN
L1.01  CONSTRUCTION PLAN
L2.00  CONSTRUCTION DETAILS
L2.01  CONSTRUCTION DETAILS
L2.02  CONSTRUCTION DETAILS
L3.00  SOIL PLACEMENT PLAN
L4.00  IRRIGATION NOTES & LEGEND
L4.01  IRRIGATION PLAN
L4.02  IRRIGATION DETAILS
STRUCTURAL

S0.01 GENERAL NOTES
S0.02 GENERAL NOTES
S0.03 COLD-FORMED STEEL FRAMING GENERAL NOTES
S0.04 ISOMETRIC VIEWS
S0.05 ISOMETRIC OF PLANETARIUM FRAMING
S0.06 DESIGN LIVE LOAD & VIBRATION CRITERIA KEY PLANS
S0.07 SEISMIC LOAD RESISTING SYSTEM DIAGRAM
S2.01 FOUNDATION PLAN AND LEVEL 1
S2.02 LEVEL 2 FRAMING PLAN
S2.03 LEVEL 3 FRAMING PLAN
S2.04 ROOF FRAMING PLAN
S2.05 SKY OBSERVATION EXTERIOR CLADDING SUPPORT PLAN
S2.06 PLAZA WALL ELEVATIONS AND DETAILS
S3.01 TYPICAL CONCRETE DETAILS
S3.02 TYPICAL CONCRETE DETAILS
S3.03 TYPICAL FOUNDATION DETAILS
S3.04 SLAB ON GRADE & RETAINING WALL DETAILS
S3.05 TYPICAL FOOTING AND THICKENED SLAB DETAILS
S3.06 TYPICAL CONCRETE GRADE BEAM DETAILS
S3.07 FOUNDATION DETAILS
S3.08 FOOTING ELEVATIONS
S4.01 BRACE FRAME ELEVATIONS
S4.02 BRACE FRAME ELEVATIONS
S4.03 BRACE FRAME ELEVATIONS
S4.04 PLANETARIUM EXTERIOR FRAME ELEVATION
S4.05 BUILDING SECTION AT PLANETARIUM
S4.06 BUILDING SECTION AT PLANETARIUM
S4.10 EXTERIOR WALL FRAME ELEVATIONS
S4.11 EXTERIOR WALL FRAME ELEVATIONS
S4.12 EXTERIOR WALL SECTIONS
S4.13 EXTERIOR WALL SECTIONS
S4.14 EXTERIOR WALL SECTIONS
S4.15 EXTERIOR WALL SECTIONS
S5.01 STEEL NON-FRAME COLUMN SCHEDULE AND DETAILS
S5.02 COLUMN SCHEDULE AND STEEL COLUMN DETAILS
S5.03 TYPICAL STEEL DETAILS
S5.04 TYPICAL STEEL DETAILS
S5.05 TYPICAL STEEL DETAILS
S5.06 STEEL DETAILS
S5.07 ROOF STEEL DETAILS
S5.08 SKY ROOF STEEL DETAILS
S5.09 SKY ROOF STEEL DETAILS
S5.10 ANCHORAGE DETAILS
S5.11 EXTERIOR CLADDING SUPPORT DETAILS
S5.12 EXTERIOR CLADDING SUPPORT DETAILS
S5.13 EXTERIOR CLADDING SUPPORT DETAILS
S5.21 TYPICAL STEEL DECK DETAILS
ARCHITECTURAL EDGE OF SLAB

AS2.1.1 LEVEL 1 SLAB EDGE PLAN
AS2.1.2 LEVEL 2 SLAB EDGE PLAN
AS2.1.3 LEVEL 3 SLAB EDGE PLAN
AS2.1.4 ROOF SLAB EDGE PLAN

ARCHITECTURAL

A0.1 ARCHITECTURAL ABBREVIATIONS AND SYMBOLS
A1.1.1 LEVEL 1 ARCHITECTURAL SITE PLAN
A1.2.1 LEVEL 2 ARCHITECTURAL SITE PLAN
A1.3.1 ARCHITECTURAL SITE DETAILS
A2.1.1 LEVEL 1 FLOOR PLAN
A2.1.2 LEVEL 1 PARTITION AND DIMENSION PLAN
A2.1.3 LEVEL 1 FINISH FLOOR PLAN
A2.2.1 LEVEL 2 FLOOR PLAN
A2.2.2 LEVEL 2 PARTITION AND DIMENSION PLAN
A9.4.5  ENLARGED TUTORIAL AREA RCP
A9.4.6  ENLARGED LEVEL 2 FACULTY CORRIDOR RCP
A9.4.7  LEVEL 3 - ENLARGED LOBBY & PLANETARIUM REFLECTED CEILING PLAN
A9.4.8  LEVEL 3 - ENLARGED LOBBY & PLANETARIUM CEILING DETAILS
A9.4.10 DSA IR 25-2.13 CEILING DETAILS AND NOTES PART 1
A9.4.11 DSA IR 25-2.13 CEILING DETAILS AND NOTES PART 2
A9.4.12 DSA IR 25-2.13 CEILING DETAILS AND NOTES PART 3 & DSA IR 25-3.13 GYP. BD.
A9.4.13 ICC ESR REPORTS FOR REFERENCE ONLY
A9.4.14 ICC ESR REPORTS FOR REFERENCE ONLY
A9.5.1 INTERIOR CONSTRUCTION DETAILS
A9.5.2 INTERIOR CONSTRUCTION DETAILS
A9.6.1 MODULAR CASEWORK SCHEDULE AND DETAILS
A9.6.2 MODULAR CASEWORK DETAILS
A9.6.3 CASEWORK DETAILS
A9.6.4 CASEWORK DETAILS
A9.7.1 CUSTOM ARCHITECTURAL CASEWORK
A9.7.2 CUSTOM ARCHITECTURAL CASEWORK
A9.7.3 CUSTOM ARCHITECTURAL CASEWORK
A9.7.4 CUSTOM ARCHITECTURAL CASEWORK
A9.7.5 CUSTOM ARCHITECTURAL CASEWORK
A9.8.1 INTERIOR GLASS DETAILS
A9.8.2 INTERIOR GLASS DETAILS
A9.9.1 MISCELLANEOUS INTERIOR DETAILS
A9.9.2 CORNER AND WALL GUARD DETAILS
A9.9.3 MISCELLANEOUS RESTROOM DETAILS
A9.9.4 MISCELLANEOUS ACOUSTICAL DETAILS
A11.1.1 LEVEL 1 SIGNAGE PLAN
A11.1.2 LEVEL 2 SIGNAGE PLAN
A11.1.3 LEVEL 3 SIGNAGE PLAN
A11.1.4 ROOF SIGNAGE PLAN
A11.2.1 SIGNAGE TYPES
A11.3.1 SIGNAGE ELEVATIONS

LABORATORY

LF001 LABORATORY FURNISHINGS KEY SHEET
LF002 LABORATORY FURNISHINGS FITTING AND EXHAUST SCHEDULE
LF003 LABORATORY FURNISHINGS CASEWORK MENU
LF004 CASEWORK ANCHORAGE DETAILS
LF100 LABORATORY FURNISHINGS LEVEL 1 OVERALL PLAN
LF101 LABORATORY FURNISHINGS LEVEL 1 PARTIAL PLAN A
LF102 LABORATORY FURNISHINGS LEVEL 1 PARTIAL PLAN B
LF200 LABORATORY FURNISHINGS LEVEL 2 OVERALL PLAN
LF201 LABORATORY FURNISHINGS LEVEL 2 PARTIAL PLAN A
LF202 LABORATORY FURNISHINGS LEVEL 2 PARTIAL PLAN B
LF300 LABORATORY FURNISHINGS LEVEL 3 OVERALL PLAN
LF301 LABORATORY FURNISHINGS LEVEL 3 PARTIAL PLAN A
LF302 LABORATORY FURNISHINGS LEVEL 3 PARTIAL PLAN B
LF303 LABORATORY FURNISHINGS LEVEL 3 PARTIAL PLAN C
LF400 LABORATORY FURNISHINGS INTERIOR ELEVATIONS
LF401 LABORATORY FURNISHINGS INTERIOR ELEVATIONS
LF500 LABORATORY FURNISHINGS EXHAUST DETAILS
LF501 LABORATORY FURNISHINGS DETAILS
LF502 LABORATORY FURNISHINGS DETAILS
LF503 LABORATORY FURNISHINGS DETAILS
# MECHANICAL

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M0.01</td>
<td>MECHANICAL LEGEND, ABBREVIATIONS, AND GENERAL NOTES</td>
</tr>
<tr>
<td>M0.02</td>
<td>MECHANICAL SCHEDULES</td>
</tr>
<tr>
<td>M0.03</td>
<td>MECHANICAL SCHEDULES</td>
</tr>
<tr>
<td>M0.04</td>
<td>MECHANICAL SCHEDULES</td>
</tr>
<tr>
<td>M0.05</td>
<td>MECHANICAL SCHEDULES</td>
</tr>
<tr>
<td>M2.01</td>
<td>MECHANICAL - LEVEL 1 FLOOR PLAN</td>
</tr>
<tr>
<td>M2.01A</td>
<td>MECHANICAL - LEVEL 1 PARTIAL PLAN A</td>
</tr>
<tr>
<td>M2.02</td>
<td>MECHANICAL - LEVEL 2 FLOOR PLAN</td>
</tr>
<tr>
<td>M2.02A</td>
<td>MECHANICAL - LEVEL 2 PARTIAL PLAN A</td>
</tr>
<tr>
<td>M2.02B</td>
<td>MECHANICAL - LEVEL 2 PARTIAL PLAN B</td>
</tr>
<tr>
<td>M2.03</td>
<td>MECHANICAL - LEVEL 3 FLOOR PLAN</td>
</tr>
<tr>
<td>M2.03A</td>
<td>MECHANICAL - LEVEL 3 PARTIAL PLAN A</td>
</tr>
<tr>
<td>M2.03B</td>
<td>MECHANICAL - LEVEL 2 PARTIAL PLAN B</td>
</tr>
<tr>
<td>M2.04</td>
<td>MECHANICAL - ROOF PLAN</td>
</tr>
<tr>
<td>M3.01</td>
<td>MECHANICAL - LEVEL 1 HYDRONIC</td>
</tr>
<tr>
<td>M3.01A</td>
<td>HYDRONIC - LEVEL 1 PARTIAL PLAN A</td>
</tr>
<tr>
<td>M3.02</td>
<td>MECHANICAL - LEVEL 2 HYDRONIC</td>
</tr>
<tr>
<td>M3.02A</td>
<td>HYDRONIC - LEVEL 2 PARTIAL PLAN A</td>
</tr>
<tr>
<td>M3.02B</td>
<td>HYDRONIC - LEVEL 2 PARTIAL PLAN B</td>
</tr>
<tr>
<td>M3.03</td>
<td>MECHANICAL - LEVEL 3 HYDRONIC</td>
</tr>
<tr>
<td>M3.03A</td>
<td>HYDRONIC - LEVEL 3 PARTIAL PLAN A</td>
</tr>
<tr>
<td>M3.03B</td>
<td>HYDRONIC - LEVEL 3 PARTIAL PLAN B</td>
</tr>
<tr>
<td>M3.04</td>
<td>MECHANICAL - ROOF HYDRONIC</td>
</tr>
<tr>
<td>M4.01</td>
<td>MECHANICAL ENLARGED PLANS</td>
</tr>
<tr>
<td>M4.02</td>
<td>MECHANICAL ENLARGED PLANS</td>
</tr>
<tr>
<td>M5.01</td>
<td>MECHANICAL AIRSIDE DIAGRAM</td>
</tr>
<tr>
<td>M5.02</td>
<td>MECHANICAL HYDRONIC DIAGRAM</td>
</tr>
<tr>
<td>M6.01</td>
<td>MECHANICAL DETAILS</td>
</tr>
<tr>
<td>M6.02</td>
<td>MECHANICAL DETAILS</td>
</tr>
<tr>
<td>M6.03</td>
<td>MECHANICAL DETAILS</td>
</tr>
<tr>
<td>M6.04</td>
<td>MECHANICAL DETAILS</td>
</tr>
<tr>
<td>M6.05</td>
<td>MECHANICAL DETAILS</td>
</tr>
<tr>
<td>M6.06</td>
<td>MECHANICAL DETAILS</td>
</tr>
<tr>
<td>M6.07</td>
<td>MECHANICAL DETAILS</td>
</tr>
<tr>
<td>M7.01</td>
<td>MECHANICAL CONTROLS</td>
</tr>
<tr>
<td>M7.02</td>
<td>MECHANICAL CONTROLS</td>
</tr>
<tr>
<td>M7.03</td>
<td>MECHANICAL CONTROLS</td>
</tr>
<tr>
<td>M7.04</td>
<td>MECHANICAL CONTROLS</td>
</tr>
<tr>
<td>M7.05</td>
<td>MECHANICAL CONTROLS</td>
</tr>
<tr>
<td>M8.01</td>
<td>MECHANICAL T24</td>
</tr>
<tr>
<td>M8.02</td>
<td>MECHANICAL T24</td>
</tr>
<tr>
<td>M8.03</td>
<td>MECHANICAL T24</td>
</tr>
<tr>
<td>M8.04</td>
<td>MECHANICAL T24</td>
</tr>
<tr>
<td>M8.05</td>
<td>MECHANICAL T24</td>
</tr>
</tbody>
</table>

# PLUMBING

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0.01</td>
<td>PLUMBING LEGEND, ABBREVIATIONS, AND GENERAL NOTES</td>
</tr>
<tr>
<td>P0.02</td>
<td>PLUMBING SCHEDULES</td>
</tr>
<tr>
<td>P1.01</td>
<td>PLUMBING - SITE PLAN</td>
</tr>
<tr>
<td>P2.00</td>
<td>PLUMBING - UNDERGROUND PLAN</td>
</tr>
</tbody>
</table>
Contra Costa Community College District
Contra Costa College
C-4016 New Science Building – Increment 2

Contra Costa Community College District
Contra Costa College
C-4016 New Science Building – Increment 2

FIRE ALARM

FA0.01 FIRE ALARM GENERAL NOTES, LEGEND
FA0.02 FIRE ALARM SCHEDULES
FA1.01 FIRE ALARM - SITE PLAN
FA2.01 FIRE ALARM - LEVEL 1 FLOOR PLAN
FA2.02 FIRE ALARM - LEVEL 2 FLOOR PLAN
FA2.03 FIRE ALARM - LEVEL 3 FLOOR PLAN
FA2.04 FIRE ALARM - ROOF PLAN
FA4.01 FIRE ALARM - ENLARGED PLANS
FA5.01 FIRE ALARM DIAGRAM
FA5.02 COMMUNICATION DIAGRAM
FA5.03 FIRE ALARM BATTERY CALCULATIONS
FA6.01 FIRE ALARM DETAILS

FIRE PROTECTION

F0.0.1 FIRE PROTECTION TITLE SHEET
F0.0.2 FIRE PROTECTION MISC. DETAILS
F0.0.3 FIRE PROTECTION MISC. DETAILS
F0.0.4 FIRE PROTECTION HANGER DETAILS
F0.0.5 FIRE PROTECTION SWAY BRACE DETAILS
F1.0.0 FIRE PROTECTION REFERENCE UNDERGROUND PIPING PLAN
F2.1.1 FIRE PROTECTION REFLECTED CEILING PLAN - LEVEL 1
F2.1.2 FIRE PROTECTION REFLECTED CEILING PLAN - LEVEL 2
F2.1.3 FIRE PROTECTION REFLECTED CEILING PLAN - LEVEL 3 & SKY OBSERVATORY
F3.1.1 FIRE PROTECTION OVERHEAD PIPING PLAN - LEVEL 1
F3.1.2 FIRE PROTECTION OVERHEAD PIPING PLAN - LEVEL 2
F3.1.3 FIRE PROTECTION OVERHEAD PIPING PLAN - LEVEL 3
F3.1.4 FIRE PROTECTION OVERHEAD PIPING PLAN - ROOF & SKY OBSERVATORY
F4.1.1 FIRE PROTECTION BUILDING SECTION
ELECTRICAL
E0.01 ELECTRICAL LEGEND
E0.02 ELECTRICAL GENERAL NOTES AND ABBREVIATIONS
E0.03 LIGHTING FIXTURE SCHEDULES
E0.04 LIGHTING FIXTURE SCHEDULES
E0.05 EQUIPMENT SCHEDULES
E0.06 DISTRIBUTION PANEL SCHEDULES
E0.07 PANEL SCHEDULES
E0.08 PANEL SCHEDULES
E0.09 PANEL SCHEDULES
E0.10 PANEL SCHEDULES
E0.11 PANEL SCHEDULES
E0.12 PANEL SCHEDULES
E1.01.V2 ELECTRICAL - SITE PLAN
E1.02.V2 LIGHTING - SITE PLAN
E1.03 LIGHTING - SITE PLAN LEVEL 2
E1.11 ELECTRICAL - ENLARGED SITE PLAN
E1.13.V2 ELECTRICAL - MANHOLE, DUCT BANK DETAIL
E2.01 LIGHTING - LEVEL 1 FLOOR PLAN
E2.02 LIGHTING - LEVEL 2 FLOOR PLAN
E2.03 LIGHTING - LEVEL 3 FLOOR PLAN
E2.04 LIGHTING - ROOF PLAN
E2.05 LIGHTING - SKY DECK PLAN
E2.06 LIGHTING - STAIRS
E3.00 POWER - UNDERGROUND PLAN
E3.01 POWER - LEVEL 1 FLOOR PLAN
E3.01A POWER - LEVEL 1 PARTIAL PLAN A
E3.02 POWER - LEVEL 2 FLOOR PLAN
E3.02A POWER - LEVEL 2 PARTIAL PLAN A
E3.02B POWER - LEVEL 2 PARTIAL PLAN B
E3.03 POWER - LEVEL 3 FLOOR PLAN
E3.03A POWER - LEVEL 3 PARTIAL PLAN A
E3.03B POWER - LEVEL 3 PARTIAL PLAN B
E3.04 POWER - ROOF PLAN
E3.05 POWER - SKY DECK PLAN
E4.01 ENLARGED ROOM PLANS
E4.02 ENLARGED ROOM PLANS
E4.03 ENLARGED ROOM PLANS
E5.00 SINGLE LINE DIAGRAM - MEDIUM VOLTAGE
E5.01 SINGLE LINE DIAGRAM - LOW VOLTAGE
E5.02 RISER DIAGRAM - GROUNDING
E6.01 ELECTRICAL DETAILS
E6.02 ELECTRICAL DETAILS
E6.03 ELECTRICAL DETAILS
E6.04 ELECTRICAL DETAILS
E6.05 ELECTRICAL DETAILS
E6.06 ELECTRICAL DETAILS
E6.07 ELECTRICAL DETAILS
E6.08 ELECTRICAL DETAILS
E6.09 ELECTRICAL DETAILS
E6.10 ELECTRICAL DETAILS
E6.11 ELECTRICAL DETAILS
E6.12 ELECTRICAL DETAILS
E6.13 ELECTRICAL DETAILS
E6.14 ELECTRICAL DETAILS
E6.15 ELECTRICAL DETAILS
E6.16 ELECTRICAL DETAILS
E6.17 ELECTRICAL DETAILS
E6.18 ELECTRICAL DETAILS
E6.19 ELECTRICAL DETAILS
E6.20 ELECTRICAL DETAILS
E6.21 ELECTRICAL DETAILS
E6.22 ELECTRICAL DETAILS
E6.23 ELECTRICAL DETAILS
E6.24 ELECTRICAL DETAILS
E6.25 ELECTRICAL DETAILS
E7.01 ELECTRICAL T24
E7.02 ELECTRICAL T24
E7.03 ELECTRICAL T24

TECHNOLOGY

T0.0.1.V2 TITLE SHEET AND INDEX
T0.0.2.V2 PATHWAY REQUIREMENTS
T0.0.3 SCHEDULES
T0.1.1 DIAGRAM - BACKBONE PATHWAYS
T0.1.2 DIAGRAM - GROUNDING
T0.1.3 DIAGRAM - CABLING
T0.2.1 DIAGRAM - SECURITY ACAMS BLOCK
T0.2.2 DIAGRAM - SECURITY VSS BLOCK
T0.3.1 DIAGRAM - AV FUNCTIONALS
T0.3.2 DIAGRAM - AV FUNCTIONALS
T2.0.1 FLOOR PLAN - LEVEL 1
T2.0.2 FLOOR PLAN - LEVEL 2
T2.0.3 FLOOR PLAN - LEVEL 3
T2.0.4 FLOOR PLAN - ROOF
T2.0.5 FLOOR PLAN - SUNKEN ROOF - MEZZANINE STAIRWELL
T2.0.6 FLOOR PLAN - OBSERVATORY
T3.0.1 REFLECTED CEILING PLAN - LEVEL 1
T3.0.2 REFLECTED CEILING PLAN - LEVEL 2
T3.0.3 REFLECTED CEILING PLAN - LEVEL 3
T4.0.0 ROOM PLANS & EQUIPMENT ELEVATION - BDF 128
T4.0.1 ROOM PLANS & EQUIPMENT ELEVATION - IDF ROOM TYPICAL
T4.0.10 ROOM PLAN - 72 OCC CLASSROOM
T4.0.11 ROOM ELEVATIONS - 72 OCC CLASSROOM
T4.0.12 ROOM PLAN - 50 OCC CLASSROOM
T4.0.13 ROOM ELEVATIONS - 50 OCC CLASSROOM
T4.0.14 ROOM PLAN - 40 OCC CLASSROOM
T4.0.15 ROOM ELEVATIONS - 40 OCC CLASSROOM
T4.0.16 ROOM PLAN - 36 OCC CLASSROOM
T4.0.17 ROOM ELEVATIONS - 36 OCC CLASSROOM
T4.0.18 ROOM PLAN - ANATOMY LAB
T4.0.19 ROOM ELEVATIONS - ANATOMY LAB
T4.0.20 ROOM PLAN - PHYSIO LAB
T4.0.21 ROOM ELEVATIONS - PHYSIO LAB
T4.0.22 ROOM PLAN - MICROBIO LAB
T4.0.23 ROOM ELEVATIONS - MICROBIO LAB
T4.0.24 ROOM PLAN - BIOTECH LAB
T4.0.25 ROOM ELEVATIONS - BIOTECH LAB
T4.0.26 ROOM PLAN - COMPUTER LAB
T4.0.27 ROOM ELEVATIONS - COMPUTER LAB
PLANETARIUM

PL.A1 PLANETARIUM ACOUSTIC TREATMENT (DEFERRED SUBMITTAL)
PL.EQ1 PLANETARIUM 30 FT DIAMETER PROJECTION DOME SUSPENSION (DEFERRED SUBMITTAL)
PL.EQ2 PLANETARIUM 5.1 SOUND SYSTEM WITH PA (DEFERRED SUBMITTAL)
PL.EQ3 PLANETARIUM EQUIPMENT LOCATION (DEFERRED SUBMITTAL)
PL.EQ4 PLANETARIUM CONTROL CONSOLE AND CENTRAL BARRIER (DEFERRED SUBMITTAL)
PL.RE1 PLANETARIUM ELECTRICAL REQUIREMENTS (REFERENCE ONLY)
PL.RE2 PLANETARIUM LED DOME LIGHTING REQUIREMENTS (DEFERRED SUBMITTAL)
PL.TE1 PLANETARIUM AUDIO, VISUAL, AND LIGHTING BLOCK DIAGRAMS (DEFERRED SUBMITTAL)

END OF SECTION 00010
SECTION 210413 - COMMON SUBMITTAL REQUIREMENTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.

      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER’S AND GENERAL CONTRACTOR’S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect’s staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:

   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.

   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.

   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect’s notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.

1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.

1. Submittal Numbering: See below.
2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition

1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.
3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).
4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering
1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.
B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.
C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.
D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 21 13 13 – WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and the general provisions of the Contract, including General and Supplementary Conditions and other Division 01 specifications sections, apply to this section.

1.2 DESCRIPTION

A. Provide a complete wet pipe automatic fire sprinkler system throughout the building, as required by the California Building Code, California Fire Code and NFPA 13, and the authorities having jurisdiction.

1.3 WORK INCLUDED

A. Furnish all labor, materials, equipment, and services required for and/or reasonably incidental to the completion of the following work. Include all such work shown on the drawings and/or listed below.

B. Provide a complete wet-pipe automatic fire sprinkler system throughout the building to provide protection as required by NFPA 13, 2016 Edition and the authority having jurisdiction.

C. Provide a complete automatic deluge (open sprinkler) system for complete sprinkler coverage below planetarium dome, design and installed per NFPA 13.

D. Provide a manual, wet, class I standpipe system in the building in accordance with NFPA 14 2016 Edition and comply with the requirements of the authority having jurisdiction.

E. Provide all sprinklers and piping. All sprinklers shall be quick response unless noted otherwise on the contract drawings or prohibited by NFPA 13 or the equipment listings.

F. Provide all main, test, and auxiliary drains, as required.

G. All painting of portions of the fire protection system required to be painted by the College, Architect or Planetarium Consultant or the project specifications or drawings.

H. Comply with all design requirements of the authority having jurisdiction.

I. Arrange for all required inspections by the authority having jurisdiction. Cost of all testing and special inspection required shall be included in this contract.

J. Provide all shop drawings of the fire protection systems as required by NFPA 13. At a minimum the drawings shall show location and type of sprinklers, piping, hangers, bracing, seismic restraint, drains, test valves, and all related items.

L. Provide all permit and inspection fees for the work under this section.

M. Provide all alarm monitoring and equipment required by NFPA 13 and 14 for a complete system installation including paddle type flow switch is to be installed at each system riser, pressure switch at deluge riser and supervisory switches on all control valves. All equipment monitoring devices required shall be provided, adjusted and tested under this contract. Monitoring of the devices shall be under a different scope.

N. Coordinate the fire sprinkler system installation with the other trades on this project.

1.4 REFERENCED STANDARDS

A. The 2016 edition of NFPA 13 and 2013 edition of NFPA 14 shall be followed. Where these specifications or the authority having jurisdiction requirements vary from these standards, the more rigid requirements shall apply.

1.5 RELATED WORK UNDER OTHER SECTIONS

A. The following is not in the work under this section, but is covered under other sections.
   1. Installation of the underground fire protection system with exception of 5’-0” stub. Refer to Site Civil utility drawings for point of connection (POC). Civil underground pipe will stop 5 feet from building.
   2. Fire Alarm Systems and the electrical wiring for the fire sprinkler supervisory system.

1.6 CODE REQUIREMENTS

A. All work shall conform to the requirements of applicable Federal, State and local building and safety codes, ordinances and regulations.

B. Nothing in this specification or on the plans shall be construed as permitting a departure from any applicable Federal, State and local building and safety codes, ordinances and regulations, or from any requirement by the authority having jurisdiction.

C. Special attention shall be given to local fire and building regulations.

D. All work shall be done in accordance with the requirements of NFPA 13, 2016 and NFPA 14, 2013.

1.7 SUB-CONTRACTOR QUALIFICATIONS

A. All work must be performed by a State licensed automatic fire sprinkler contractor regularly and currently engaged in the installation of fire protection systems.

1.8 SHOP DRAWINGS AND SUBMITTALS

A. Before commencing any work or providing any materials at the job site for this project, this contractor shall submit to the Owner's Representative, for approval, Shop Drawings and Material Data Sheets. Shop drawings shall be in compliance with NFPA 13, NFPA 14 and include any local requirements. Material Data Sheets should contain the manufacturer's data regarding all material and equipment intended for use on this project.
B. Within thirty (30) days submit shop drawings to the Owner's Representative for review. These drawings shall include layout of all piping and valves.

C. Within thirty (30) days submit 6 copies of all materials to be used. Submittal shall include valves, pipe, fittings, etc., for review prior to any fabrication or installation.

D. After making corrections as indicated by the Owner's Representative, submit shop drawings to all authorities for approval.

E. This contractor must submit detailed shop drawings and inspection certificates to the authority having jurisdiction, and secure approval thereof, so as to cause no delay to construction schedule.

F. Upon completion of the project, submit final "as built" record drawings and calculations detailing installed supply piping, system control valves, main and branchline piping, and sprinkler head locations.

G. Upon completion of the job, furnish the Owner's Representative with a copy of the “Contractors Material and Test Certificate” signed by the authority having jurisdiction.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Overhead piping, fittings and certain hanger material shall conform to the requirements outlined in NFPA 13 and NFPA 14, all other material shall be listed in the Underwriters Laboratories, Inc., Fire Protection Equipment List, and the Factory Mutual Approval Guide, for use as intended in overhead automatic fire sprinkler and standpipe system installations, and shall be acceptable to the authority having jurisdiction. Material that is pending approval shall not be acceptable.

B. Fittings and couplings that are designed to be installed on plain end pipe or which incorporate set screws shall not be used. Fittings shall be designed to withstand earthquake forces and local vibration, which may be present in the building.

C. All sprinklers below ceilings are to be pendent style as noted on the fire protection drawings.

D. All sprinklers above ceilings are to be upright or pendent style as noted on the fire protection drawings.
E. Any pipe and fittings installed outside of the building and exposed to the elements shall be galvanized or painted to protect against corrosion.

F. Bushings shall not be used unless specifically approved.

G. All threaded pipe shall be Allied Tube Schedule 40 black steel or equal. UL Listed and FM Approved.

H. All grooved pipe shall be Allied Tube Schedule 10 black steel or equal. UL Listed and FM Approved.

I. All grooved fittings to be Victaulic or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. It is the intent of these specifications that this contractor install the fire protection system to meet the specifications contained herein, including the various design and performance criteria delineated and to be responsible for the actual performance of the system according to these criteria.

B. Prior to bid, visit the job site; take measurements and other such information. Compare this with the drawings and specifications as to the conditions under which the work is to be performed. No allowance shall be subsequently made for extra expenses due to failure or neglect to make such an examination.

C. All piping shall be installed as required by NFPA 13, NFPA 14 and in a manner acceptable to the authority having jurisdiction.

D. All piping shall be pressure tested and flushed according to the procedures set forth in NFPA 13 and NFPA 14.

E. Sprinklers installed where they may be exposed or subjected to mechanical damage shall be furnished with head guards.

F. All piping shall be concealed unless shown as exposed on the contract drawings.

G. Installation of the sprinkler system shall not be started until complete plans and hydraulic calculations have been approved by the authority having jurisdiction.

H. All equipment installed under this contract shall be protected from external damage, including, but not limited to corrosion and settlement.

I. This contractor shall be responsible for any damage to other work caused by his installation or by leaks in the fire protection lines.

J. All work shall be done in a neat and workman like manner.

3.2 AS BUILT DRAWINGS
A. Keep a current set of “as-built” drawings on the job site at all times. These drawings should be updated as changes are made.

B. Keep a current set of Material Data Sheets, with catalog cuts, on the job site at all times.

3.3 CLEAN UP

A. Perform the work under this section so as to keep affected portions of the site neat, clean and orderly at all times. Upon completion of the work under this section, remove immediately all surplus materials, rubbish and equipment associated with or used in the performance of this work. Failure to perform such cleanup operations within 24 hours of notice by the Owner's Representative shall be considered adequate grounds for having the work done by others at contractor's expense.

END OF SECTION
SECTION 22 00 00 – PLUMBING GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Division 01.

B. The requirements of the General Conditions and Supplementary Conditions.

1.2 SUMMARY

A. Furnish and install a complete (fully tested, adjusted, and ready for operation) plumbing system as described by the Contract Drawings and Specifications.

B. The design described in the Project documents reflect a building designed for low consumption of energy and water and minimum environmental footprint. Any modifications to the systems described herein shall maintain or improve on the sustainability and energy efficiency features of the project.

C. All design modifications that pertain to system selection, system energy efficiency, water and energy use, material selection and indoor air quality issues shall require the approval of Integral Group.

D. Include incidental details not usually shown or specified, but necessary for proper installation and operation.

E. Check, verify, and coordinate Work with Contract Drawings and Specifications prepared by all other trades. Include modifications, relocations, and adjustments necessary to complete work or avoid interference with other trades.

F. Where architectural features govern location of Work, refer to Architectural Drawings.

G. Contractor may install additional piping, fittings, and valves, not shown on the drawings, for testing purposes or convenience of installation. Where such materials are installed, they shall comply with the specifications and shall be properly sized for the system and operation. Remove such installed materials when they interfere with design conditions or as directed by the Architect.

H. LEED: This building shall be LEED certified. Contractor and their subs shall provide all relevant support documentation pertaining to the LEED credits that relate to their work.

I. Commissioning: The scope of work for the Contractor shall not include the duties of the Commissioning Authority (CxA). Contractor will be required, however, to include in their scope of work duties relevant to the commissioning process, including but not limited to training of owner's personnel in the operation of the plumbing equipment, providing manufacturer's startup and pre functional checklists and contractor-provided pre-functional and startup checklists to Commissioning Authority, performing and documenting pre-functional tests for plumbing equipment, performing and documenting functional tests for plumbing equipment, supporting DDC Contractor and Test and Balance Contractor in the performance of their duties, and
providing operations and maintenance manuals. Refer to Division 23 “Commissioning of HVAC and Plumbing” for additional requirements.

1.3 CODES AND STANDARDS

A. All work and materials shall be in full accordance with the latest local rules and regulations, applicable sections of the California Code of Regulations, Title 24, State Fire Marshal, the Safety Orders of the Division of Industrial Safety, the California Electric Code and applicable State requirements. Nothing in these Plans and Specifications is to be construed to permit work not conforming to these requirements.

B. Wherever the Specifications call for or describe materials or construction of better quality or larger sizes than are required by the above rules and regulations, these Specifications shall govern. Should there be any direct conflict between the above rules and regulations and the Specifications the rules shall govern.

C. Equipment shall have UL label listing.

1.4 DRAWINGS

A. Layout of the equipment and work is diagrammatic, unless specifically dimensioned. Drawings and details shall be checked for interferences before installing the work. Any interference noted between different drawings, and between drawings and actual field conditions shall be brought to the attention of the Architect and Engineer of Record for a decision. The right is reserved to make any reasonable change in location of equipment without additional expense to the Owner.

B. For purposes of clarity and legibility, drawings are diagrammatic to the extent that many offsets, bends, special fittings, exact locations of items are not indicated, unless specifically dimensioned. Exact routing of piping and locations of equipment shall be governed by structural conditions and obstructions. Contractor shall make use of all data in Contract Drawings and Specifications and field conditions.

C. In the event a major re-routing of a system appears necessary, Contractor shall prepare and submit for approval, shop drawings of the proposed rearrangement. Because of the diagrammatic nature and small scale of the Contract Drawings, all necessary offsets, adjustments, and transitions required for the complete installation are not shown. Contractor shall carefully investigate the structural and finish conditions affecting all the Work and shall arrange such Work accordingly, furnishing such fittings, equipment, accessories, etc., as may be required to meet such conditions, at no increase in Contract Sum.

D. The construction documents for this project were prepared by the design team using BIM (Building Information Modeling). Using this software by the design team does not relieve the Contractor from performing the necessary coordination to provide complete, code compliant and operational building systems. The plans and sections provided are diagrammatic and show the design intent, these are not intended to be used for fabrication or installation. Contractor is responsible for generating shop drawings for fabrication that meet the design intent as shown on the Contract Documents. The exact location of the piping, electrical and support components are to be determined by the Contractor. All building sections and details provided are for information only and do not relieve the Contractor from performing final coordination. Contractor is responsible for coordinating with all other trades.
E. All dimensions and locations of equipment, doors, partitions, etc., are to be taken from the architectural plans but shall be verified at the site.

1.5 SUBMITTALS

A. See Division 01 “Administrative Requirements”, for submittal procedures.

B. Plumbing and related submittals are, in addition, subject to the requirements of this Article. In the event of a conflict between the requirements of Division 01 and this Article, the requirements of this Article shall supersede and take precedence over those of Division 01.

C. Engineer of Record will review submittals and provide comments within the following timeframe after receipt by the Engineer:
   1. For typical submittals, allow 10 working days.
   2. For large or complex submittals, allow 15 working days. Determination of “large and complex” submittal shall be at the discretion of the Engineer of Record.
   3. Do not send Engineer of Record more than 10 submittals in a contiguous period of 5 working days. If excess submittals are received, review period will be extended as necessary to perform proper review. Submittals will be reviewed in priority determined by Engineer of Record in consultation with Architect and Contractor.
   4. These submittal review periods supersede and take precedence over periods defined in Division 01, unless Division 01 allows for longer review periods.
   5. Submittal review periods shall not be reduced from the times herein except by agreement with the reviewing entity, in advance and in writing.

D. Submittal documentation and drawings shall consistently use the same abbreviations, symbols, nomenclature and identifiers. Use the same identifiers (e.g. equipment tags) used in Contract Drawings.

E. Submittals shall be provided in digital format.
   1. Provide a separate file for each submittal. For submittal packages, provide a separate file for each subsection (e.g. hardware cutsheets and shop drawings for the same Section shall be provided as separate files).
   2. Product cutsheets, test forms and other text documents shall be provided in word searchable digital format. Acceptable formats are MS Word, PDF (generated from another electronic document and word-searchable; scans of paper documents are not acceptable), and HTML; other formats require approval prior to submission.
   3. Drawings and schematics shall be provided in PDF format and in AutoCAD compatible format.
   4. Scanned paper documents are not acceptable
      a. Exception: original signed documents, such as qualifications, inspection certificates, and warranty documents.
   5. Hardcopy (paper) submittals are not acceptable and shall not be provided except as noted in Article 1.2).
   6. Submittals provided in the wrong format will be returned without action.

F. Submission and Resubmission Procedure
   1. Optional Pre-Submittals: At Contractor’s option, material may be submitted unofficially via email directly to the Engineer of Record for review and comment prior to formal submission. Comments provided by the Engineer are not official and may be changed or additional comments may be provided on the formal submittal. The intent of pre-
submittals is to reduce paperwork and review time, and to provide a venue to discuss technologies, products, designs or implementation strategies that are novel or unique.

2. Each submittal shall have a unique serial number that includes the associated Specification Section followed by a number for each sub-part of the submittal for that Specification Section, such as SUBMITTAL 220000-01. There is no requirement to assign particular serial numbers to any specific submittals – serial number assignment is arbitrary. The only requirements are that the serial numbers be sequential (to avoid confusing gaps) and, most importantly, consistent across all submittal correspondence.

3. Each resubmittal shall have the original unique serial number plus unique revision number such as SUBMITTAL 220000-01 REVISION 1.

4. Submit one copy of submittal in electronic format specified in Paragraph 1.5E. Submissions made in the wrong format will be returned without action.

5. Include with each submittal and resubmittal a copy of the relevant specification section(s) noting on each paragraph and sub-paragraph(s) the following:
   a. CONFORMS: Contractor has verified that the submitted product conforms to the noted requirement(s).
   b. CONFORMS AS NOTED: Contractor has verified that the submitted product conforms to the noted requirement(s) by means of being equal to or higher quality and / or performance.
   c. NON-CONFORM: Contractor has verified that the submitted product does not conform to the noted requirement(s) and delineates each deviation from the specification requirements.
   d. NOT APPLICABLE: Contractor has verified that the noted requirement(s), in their opinion do not apply to this product, delineating the reasons for this decision.
   e. Include with each submittal and resubmittal a copy of the relevant specification section(s) the printed name of the contractor reviewer, their signature, the company name, and date of review.

6. Revise submittal
   a. Respond to all comments:
      1) Revise initial submittal to resolve review comments and corrections.
      2) Provide complete responses to comments or suggestions which are not practical to implement in the opinion of the Contractor.
   b. Indicate any changes that have been made other than those requested.
   c. Clearly identify resubmittal by original submittal number and revision number.
   d. Resubmittals that are not responsive to all comments will be returned without action.

7. Resubmit revised submittals until no exceptions are taken.

8. Once submittals are accepted with "No Exceptions Taken" or "Approved As Noted", provide:
   a. Complete submittal of all accepted drawings and products in a single electronic file.
   b. Copies for coordination with other trades, if and as required by the General Contractor or Owner’s Representative.

G. Submit shop drawings, a list of proposed material and equipment manufacturers and the names of Subcontractors.

H. Shop drawings shall be provided for all plumbing systems for all floors of the building. Plumbing shop drawings shall also be provided for the underslab systems (under the foundation slab) and slab-embedded systems such as floor drains.
I. Materials and methods with which the words "for approval" or "approved" are used, and materials and methods which differ from those specified, shall be submitted.

J. Prepare and submit shop drawings, sections, details and diagrams to minimum scale 1/4" = 1'-0". Drawings shall be coordinated, dimensioned and indicate equipment, pipe, duct, fire protection, and electrical in relation to architectural and structural features. Include minor piping, drains, air vents, etc. Indicate exact locations and elevations of valves, piping specialties, access doors, dampers, etc. Electronic submittal is encouraged.

K. Submit manufacturer's specifications, product source, data sheets, certified equipment drawings and installation instructions, including installation dimensions, clearances, weights, materials, finishes, color selection, accessories, acoustical characteristics, capacity and full load and part load performance curves; complete with electrical data, motor horse power, KW; motor efficiency, amperage, voltage phases and wiring diagrams. Identify the particular specification section number, paragraph and equipment identification number per equipment schedule. Note that suppliers (wholesalers and distributors) data sheets are not acceptable unless they are also manufacturers of the product being submitted.

L. Pump systems, with equipment in parallel, shall have performance curves noting single equipment operation and all iterations of additional equipment.

M. Certified Equipment Drawings (8-1/2" x 11" sheets) shall be indexed in accordance with Specification Section. Drawings to be submitted at a later date shall be marked with a page as a placeholder for insertion when submitted. The original submittal shall note which shop drawings will be submitted later. Marked-up catalogs are not acceptable and will be returned without action. Electronic submittal is required.

N. Engineer of Record’s review of submittals is for limited purpose of verifying conformance with information given and design concept expressed in Contract Drawings and Specifications. Engineer’s review is not for purpose of determining accuracy or completeness of items such as dimensions and quantities, which remain responsibility of Contractor.

O. Contractor shall not commence with fabrication or installation of any equipment or system until the associated submittals have been approved by the Engineer of Record and returned with "no exceptions" taken. Contractor shall be solely liable for any costs incurred from starting fabrication before approved submittals are returned.

P. All final approved submittals and equipment datasheets shall be provided, in PDF format, to the owner as part of the as-built drawing set and shall be text searchable.

1.6 COORDINATION DRAWINGS

A. Utilize the latest version of 3D AutoCAD, Navisworks, and/or Revit software for the Coordination Drawings. No proprietary software of any kind shall be used other than that indicated. Drawing paper size shall not be larger than FULL SIZED Contract Drawings, and in no case larger than 30” x 42”. Coordinate available space with ALL other trades involved.

B. Provide Coordination Drawings in digital electronic format. Provide both native file format (AutoCAD, Navisworks, or Revit) and PDF format files. Hardcopy drawings are not acceptable.

C. These drawings are to show pipe sizes, valves and accessories, elevation of bottom of pipe, all elevations of materials and/or systems throughout each floor inclusive of hanger components, seismic bracing if applicable, and any component of construction that impacts vertical and/or
horizontal space. In addition, the locations of all valves and other items requiring access for service and maintenance are to be shown. The drawings are to also show electrical, structural beams, architectural bracing, structural bracing, ceiling heights, access doors, walls, floor to floor dimensions, columns, doors and other major architectural and structural features as shown on the architectural and structural drawings. Where the routing of work differs from that indicated on the Contract Drawings, such areas are to be indicated by highlighting with a note describing the reason for the change.

D. Rerouting of any system or part thereof shall be submitted separately in order to obtain concurrence of the Engineer of Record. Submitted rerouting must include fully documented proposed solutions with all trades coordinated. Contractor is fully responsible for coordination of systems included herein. Any effort by Engineer of Record beyond answering Contractor’s questions will be at Contractor’s expense, including attending coordination meetings, review of interim plans, or review of incomplete questions (routing issues without suggested solutions).

E. The Contractor and subcontractors are responsible to review and resolve any real or apparent interferences or conflicts as indicated by the coordination drawings produced by each trade.

F. After all conflicts or interferences are resolved, develop a final composite drawing showing the agreed upon routing, layout and juxtaposition of all piping, major conduit, valves, panels, lighting fixtures and all other major mechanical, plumbing and electrical installations. In the preparation of all the final Coordination Drawings, large scale details as well as cross and longitudinal sections are required to fully delineate all conditions.

G. Submit the Coordination Drawings as digital electronic files to Engineer of Record for review and comment, as indicated under “Shop Drawings” above. Coordination Drawings shall be digitally signed-off by all other trades.

H. Contractor shall not commence with fabrication or installation of any equipment or system until the associated shop drawings have been reviewed and returned by the Engineer of Record. Engineer’s review of shop drawings shall not be taken as approval of their contents. Contractor shall be solely liable for any costs incurred due to deviations from the Contract Drawings.

I. No extra compensation will be paid for relocating any pipe, duct, conduit, or other material that has been installed without proper coordination between all trades involved. If any improperly coordinated work, or installed work that is not in accordance with the approved coordination composites, or is specifically noted by the Architect or Engineer of Record for a valid reason, necessitates additional work by the other trades, the costs of all such additional work is to be borne solely by the Contractor.

J. All changes in the scope of work due to revisions formally issued and approved are to be shown on both the individual subcontractor’s Shop Drawings and the Coordination Drawings.

1.7 REQUESTS FOR INTERPRETATION AND CLARIFICATION

A. See Division 01 “Project Management”, for RFI procedures and forms.

B. Plumbing RFIs are, in addition, subject to the requirements of this Article. In the event of a conflict between the requirements of Division 01 and this Article, the requirements of this Article shall supersede and take precedence over those of Division 01.

C. Limit each RFI to a single issue or group of related issues.
D. Each RFI shall include a workable no-cost or lowest cost solution recommendation by Contractor.

E. Allow three (3) working days from time of RFI receipt by Engineer of Record for review and response.

F. Do not send Engineer of Record more than 10 RFIs in a contiguous period of 5 working days. If excess RFIs are received, review period will be extended as necessary to provide a professional response. RFIs will be reviewed in priority determined by Engineer of Record in consultation with Architect and Contractor.

1.8 MATERIALS AND SUBSTITUTIONS

A. Comply with Division 01 “Product Requirements”.

B. Requests for product or equipment substitution shall be accompanied by a marked up copy of the Engineer of Record's original specification. For each specified product feature or requirement, Contractor shall note the equivalent feature or attribute of the proposed substitute product or equipment.

C. Shop drawings of proposed material and equipment that differ from the specified materials and equipment, shall be accompanied by drawings that define changes. These drawings shall show modifications of architectural, plumbing, electrical and mechanical work required by the proposed materials and equipment, such as relocation of flues, drains, revised electrical circuits, relocation of roof or wall penetrations, revised foundations, etc.

1.9 COORDINATION WITH OTHER WORK

A. Contractor performing Work under this Section shall become thoroughly familiar with the Drawings and Specifications. Contractor shall adjust the Work to conform with the conditions shown on these drawings to provide the best possible assembly of the combined Work.

B. Obtain necessary information from the other trades regarding location of their work in order that the Work in this Section may be placed in correct position.

C. The inclusion and proper location of supports, pads, sleepers, openings, anchorages, etc. provided by others is the responsibility of the Contractor under this Section. Cutting and/or boring shall be permitted under this Section only with the written approval of the Architect.

D. It shall be the Contractor's responsibility to coordinate and have provided by other trades where not covered by the Contractor's scope of work, all electrical wiring and power to equipment, controls and devices, and any other work from other trades as required to provide fully functioning plumbing systems per the Contract Drawings and Specifications.

1.10 MANUFACTURER'S DIRECTIONS

A. Manufacturer's directions shall be followed in cases where the manufacturers of articles used in this contract furnish directions covering points not shown in the Contract Drawings and Specifications.
1.11 PROTECTION OF WORK

A. Equipment and materials shall be stored on dunnage and remain wrapped at all times until installed.

B. Duct and piping shall be remain capped during delivery and storage.

C. During installation, all installed duct and piping shall be capped and protected at the end of each working day.

D. Equipment shall be protected from weather and stored in an enclosed, indoor location.

E. Until final acceptance of the work, protect materials from damage and provide adequate and proper storage facilities. Replace damaged or defective work, material, and equipment before requesting final acceptance.

1.12 WORKMANSHIP

A. Equipment and materials shall be installed in a neat and workmanlike manner. Materials and equipment not so installed shall, upon order of the Architect or Engineer of Record, be removed and replaced in a satisfactory manner, without change in Contract Sum or additional cost to the Owner.

1.13 CLOSING IN UNINSPECTED WORK

A. Do not allow or cause any work to be covered up or enclosed until it has been inspected, tested, and accepted by the Architect, Engineer of Record, and/or Commissioning Authority.

B. Any work enclosed or covered-up prior to inspection and testing shall be uncovered. After the work has been tested, inspected and accepted, repair such materials as may be necessary to restore disturbed work to its original and proper condition at no extra cost to the Owner.

1.14 EQUIPMENT ANCHORING

A. Equipment shall be securely anchored to the building structure to prevent shifting or overturning during earthquakes.

1.15 PRELIMINARY OPERATION

A. Under this section, Contractor shall supervise and direct preliminary operation of systems should the Owner demand that any portion of the plant, apparatus, or equipment be operated previous to the final completion and acceptance of the work. Expenses for such preliminary operation will be paid by the Owner. Such preliminary operation or payment shall not be construed as an acceptance of the work.

1.16 CUTTING AND OPENINGS

A. Comply with Division 01 “Cutting and Patching”.

Contra Costa Community College District
Contra Costa College
C-4016 New Science Building - DSA Backcheck
1.17 "AS-BUILT" DRAWINGS
   A. Comply with Section Division 01 “Project Closeout”.
   B. As-built drawings shall be furnished in an electronic format. Provide in drafting software (AutoCAD or Revit) native format and also in PDF format.

1.18 FINAL INSPECTION
   A. At the time of final inspection, a service representative shall be available to make final adjustments.

1.19 FINAL OPERATION
   A. After acceptance of the installation, instruct the Owner's Representative in operation and maintenance, for a period of three (3), non-consecutive working days at a time requested by the Owner during the first year of warranty.
   B. At the beginning of the instruction period, deliver to the Owner three (3) copies of a durable binder as described under "Operating Instructions".

1.20 OPERATING INSTRUCTIONS
   A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these Specifications.
   B. Division 22 shall compile and prepare documentation for all equipment and systems covered in Division 22 and deliver this documentation to the General Contractor for inclusion in the O&M manuals prior to the training of Owner personnel.
   C. Provide a summary of operating sequences (start-up, normal run, and shut-down), and control shop drawings in the main mechanical room.
   D. Provide three (3) complete sets of Operating Instructions. These instructions shall include brochures, diagrams, maintenance, and operating instructions and parts lists. See Article 1.19 "Final Operation”.
   E. Provide a copy of the O&M manuals to the Commissioning Authority for review.

1.21 TRAINING OF OWNER PERSONNEL
   A. The General Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.
   B. The Commissioning Authority (CxA) shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment.
   C. The Plumbing Contractor shall have the following training responsibilities:
      1. Provide the CxA with a training plan two weeks before the planned training.
2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of equipment including, but not limited to, pumps, heaters, controls, water treatment systems, etc.

3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

5. The appropriate trade or manufacturer’s representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

6. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

7. Training shall include:
   
a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
   c. Discussion of relevant health and safety issues and concerns.
   d. Discussion of warranties and guarantees.
   e. Common troubleshooting problems and solutions.
   f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
   g. Discussion of any peculiarities of equipment installation or operation.
   h. Instruction in the use of equipment controls that are integral to equipment or are provided by the equipment manufacturer. Equipment controls training shall include at least the following:

   1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system and any interface with security and communication systems.
   2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
   3) If system supports trending, all trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.
   4) Every screen shall be completely discussed, allowing time for questions.
   5) Use of keypad or plug-in laptop computer for mobile control access.
   6) Use of remote access to the system via phone lines or networks, if applicable.
   7) Graphics generation, if applicable.
   8) Point database entry and modifications, if applicable.

j. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate. A video record of the training session is suggested but not required.

8. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.

9. The Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

10. Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

1.22 WARRANTY

A. In accordance with Division 01 Project Closeout requirements, Guarantees, Warranties, Bonds, Service & Maintenance Contracts and as follows.

B. Contractor shall leave entire installation in complete working order and free from defects in material, workmanship, or finish.

C. Warranty all materials, equipment, apparatus, and workmanship to be free of defective materials and faulty workmanship for a minimum period of one (1) year from date of Certificate of Occupancy, or per Division 01, whichever is longer.

D. Warranty also services including instructions, adjusting, testing, noise, balancing, etc.

E. For each piece of equipment or device with a manufacturer’s warranty in excess of one year, Contractor shall furnish certificate of manufacturer’s warranty and contact information for manufacturer’s warranty service. Contractor shall also provide a list or table of all equipment with warranties exceeding one (1) year in duration.

F. Provide new materials, equipment, apparatus, labor and/or service, and support to correct or replace that determined by the Owner to be defective or faulty.

G. The Owner reserves the right to make temporary repairs as necessary to keep equipment in operating condition without voiding the guarantees or relieving responsibility during the guarantee period.

H. After a period of 90 calendar days from date of acceptance of systems by Owner, provide, at no cost to the Owner, one service mechanic for an 8-hour period over as many working days as required to repair, replace any latent deficiency.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION
SECTION 220413 - COMMON SUBMITTAL REQUIREMENTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
   a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Refer to Section 01330 for quantity of days allowed for review.
2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements” are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER’S AND GENERAL CONTRACTOR’S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect’s staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect’s notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.
   1. Action Code for Information Only:
      a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
   1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.
3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).
4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be ‘broken out’ for special handling. Arrange submittals accordingly.

C. Submittal Numbering
1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.
B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.
C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.
D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 22 05 13 COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes general requirements for single-phase and poly-phase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION
   A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
      1. Motor controllers.
      2. Torque, speed, and horsepower requirements of the load.
      3. Ratings and characteristics of supply circuit and required control sequence.
      4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS
   A. Comply with NEMA MG 1 unless otherwise indicated.
   B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS
   A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
   B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class B.

J. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.
2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
   1. Permanent-split capacitor.
   2. Split phase.
   3. Capacitor start, inductor run.
   4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (NOT USED)

END OF SECTION
SECTION 22 05 17 SLEEVES AND SLEEVE SEALS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Stack-sleeve fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral water stop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Zurn Industries, LLC.
2.3 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. HOLDRITE.
   2. Link-Seal - GPT Industries.
   3. Proco Products.

B. Description: Manufactured plastic, sleeve-type, water-stop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber water-stop collar with center opening to match piping OD.

2.4 GROUT


B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
   2. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

C. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 92 00 "Joint Sealants."
D. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 13 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 62 00 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 13 "Penetration Firestopping."

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water-stop flange to be centered in concrete slab or wall.
C. Secure nailing flanges to concrete forms.
D. Using grout, seal the space around outside of sleeve-seal fittings.

3.4 SLEEVE SCHEDULE

A. Use sleeves for the following piping-penetration applications:
1. Exterior Concrete Walls above Grade:
   b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-pipe sleeves.
2. Exterior Concrete Walls below Grade:
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.

5. Interior Partitions:
   a. Piping Smaller Than NPS 6 Galvanized-steel-pipe sleeves
   b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves
SECTION 22 05 18 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary
      Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section Includes:
      1. Escutcheons.
      2. Floor plates.

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS
   A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
   B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
   C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
   D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

2.2 FLOOR PLATES
   A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
   B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

1. Escutcheons for New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge or split-plate, stamped-steel type with exposed-rivet hinge.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   g. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.
2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION
SECTION 22 05 19 - METERS AND GAUGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Bimetallic-actuated thermometers.
   2. Thermowells.
   3. Dial-type pressure gauges.
   4. Gauge attachments.
   5. Test plugs.
   6. Test-plug kits.
   7. Sight flow indicators.
   8. Metering.

B. Related Sections:
   1. Section 22 11 16 "Domestic Water Piping" for water meters inside the building.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gauge, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gauges to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ashcroft Inc.
   2. Trerice, H. O. Co.
3. Weksler Glass Thermometer Corp.


C. Case: sealed type(s); stainless steel with 3-inch nominal diameter.

D. Dial: Non reflective aluminum with permanently etched scale markings and scales in deg 200F.

E. Connector Type(s): Union joint, rigid, bottom, with unified-inch screw threads.

F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.

G. Stem: 0.25 or 0.375 inch in diameter; stainless steel.

H. Window: Plain glass.

I. Ring: Stainless steel.

J. Element: Bimetal coil.

K. Pointer: Dark-colored metal.

L. Accuracy: Plus or minus 1 percent of scale range.

2.2 THERMOWELLS

A. Thermowells:
   2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
   3. Material for Use with Copper Tubing: CNR or CUNI.
   4. Material for Use with Steel Piping: CRES.
   5. Type: Stepped shank unless straight or tapered shank is indicated.
   6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
   7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
   8. Bore: Diameter required to match thermometer bulb or stem.
   9. Insertion Length: Length required to match thermometer bulb or stem.
   10. Lagging Extension: Include on thermowells for insulated piping and tubing.
   11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3 PRESSURE GAUGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gauges:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Ashcroft Inc.
      b. Trerice, H. O. Co.
      c. Weksler Glass Thermometer Corp.
3. Case: Sealed Solid-front, pressure relief type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Non reflective aluminum with permanently etched scale markings graduated in psi.
9. Window: Glass or plastic.
10. Ring: Metal.
11. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

2.4 GAUGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.5 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Trerice, H. O. Co.
   2. Weiss Instruments, Inc.
   3. Weksler Glass Thermometer Corp.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Core Inserts: EPDM self-sealing rubber.

2.6 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Trerice, H. O. Co.
   2. Watts; a Watts Water Technologies company.
   3. Weiss Instruments, Inc.

B. Furnish one test-plug kit(s) containing one thermometer(s), one pressure gauge and adapter, and carrying case. Thermometer sensing elements, pressure gauge, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.
C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

D. Pressure Gauge: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig.

E. Carrying Case: Metal or plastic, with formed instrument padding.

2.7 SIGHT FLOW INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Emerson Process Management; Rosemount Division.
   2. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
   3. Pentair Valves & Controls; Penberthy Brand.

B. Description: Piping inline-installation device for visual verification of flow.

C. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.

D. Minimum Pressure Rating: 150 psig.

E. Minimum Temperature Rating: 200 deg F.

F. End Connections for NPS 2 and Smaller: Threaded.

G. End Connections for NPS 2-1/2 and Larger: Flanged.

2.8 METERING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Badger Meter, Inc.
   2. Neptune Technology Group Inc.
   4. Elster

B. Meters capable of the following:
   1. Recording daily water consumption.
   2. Communicating data remotely. Pulse output to BMS.
   3. Electronic data storage for five years.
   4. Reports showing daily, monthly, and annual water consumption.
   5. Alarming capability in accordance with Water User Efficiency Plan for Operation.

C. Meter potable and reclaimed water sources to the building and onsite non-potable water sources individually.

D. Submeter the following, when required:
   1. Automatically controlled irrigation systems.
2. Makeup-water lines to mechanical equipment including to and from blowdown lines from cooling towers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.

H. Install remote-mounted pressure gauges on panel.

I. Install valve and snubber in piping for each pressure gauge for fluids.

J. Install test plugs in piping tees.

K. Install thermometers in the following locations:
   1. Inlet and outlet of each water heater.
   2. Inlets and outlets of each domestic water heat exchanger.
   3. Inlet and outlet of each domestic hot-water storage tank.

L. Install pressure gauges in the following locations:
   1. Building water service entrance into building.
   2. Inlet and outlet of each pressure-reducing valve.
   3. Suction and discharge of each domestic water pump.

3.2 CONNECTIONS

A. Install meters and gauges adjacent to machines and equipment to allow service and maintenance of meters, gauges, machines, and equipment.

3.3 ADJUSTING

A. Adjust faces of meters and gauges to proper angle for best visibility.
3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be one of the following:
   1. Sealed, bimetallic-actuated type.
   2. Test plug with EPDM self-sealing rubber inserts.

B. Thermometers at inlets and outlets of each domestic water heat exchanger shall be the following:
   1. Sealed, bimetallic-actuated type.
   2. Test plug with EPDM self-sealing rubber inserts.

C. Thermometers at inlet and outlet of each domestic hot-water storage tank shall be the following:
   1. Sealed, bimetallic-actuated type.
   2. Test plug with EPDM self-sealing rubber inserts.

D. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F.

B. Scale Range for Domestic Hot-Water Piping: 30 to 240 deg F.

3.6 PRESSURE-GAUGE SCHEDULE

A. Pressure gauges at discharge of each water service into building shall be the following:
   2. Test plug with EPDM self-sealing rubber inserts.

B. Pressure gauges at inlet and outlet of each water pressure-reducing valve shall be the following:
   2. Test plug with EPDM self-sealing rubber inserts.

C. Pressure gauges at suction and discharge of each domestic water pump shall be the following:
   2. Test plug with EPDM self-sealing rubber inserts.

3.7 PRESSURE-GAUGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping: 0 to 100 psi.

B. Scale Range for Domestic Water Piping: 0 to 160 psi.

END OF SECTION
SECTION 22 05 23 - GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Ball valves.
   2. Butterfly valves.
   3. Check valves.

B. Related Sections:
   1. Section 22 05 53 "Identification for Plumbing Piping and Equipment".
   2. Section 22 11 16 "Domestic Water Piping".
   3. Section 22 13 16 "Sanitary Waste and Vent Piping".
   4. Section 22 14 13 "Storm Drainage Piping".

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer rubber.

C. PTFE: Polytetrafluoroethylene.

1.4 ACTION SUBMITTALS

A. See Division 01 and Section 22 00 00 “Plumbing General Requirements” for submittal procedures.

B. Product Data: For each type of valve.
   1. Certification that products that come into contact with potable water comply with NSF 61 Annex G and NSF 372.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: for each type of valve to include in operation and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, soldered ends, and grooves.
4. Set butterfly valves closed or slightly open.

B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. Valves shall be manufactured in the United States.

C. Coordinate joint connection with Valve schedule in Part 3 and piping system specifications.

D. ASME Compliance:
   1. ASME B1.20.1 for threaded end valves.
   2. ASME B16.1 for flanges on iron valves.
   3. ASME B16.5 for flanges on steel valves.
   4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   6. ASME B31.9 for building service piping valves.

E. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.


G. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

H. Valve Actuator Types:
   1. Gear Actuator: For valves NPS 8 and larger.

I. Valves in Insulated Piping: With 2-inch stem extensions; operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.

J. All plumbing components including but not limited to valves and other wetted parts shall be lead free.
2.2 BALL VALVES

A. Two-Piece, Bronze Ball Valves with Full Port:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. NIBCO INC.
      b. Hammond Valve.
      c. Milwaukee Valve Company.
   2. Description: Two-Piece bronze body, chrome-plated brass ball, bronze trim, PTFE seat, steel handle with plated plastisol coating, \textbf{600 psig (4140 kPa)} CWP rating.

B. Steel Ball Valves with Full Port:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. NIBCO INC.
      b. Hammond Valve.
      c. Milwaukee Valve Company.
   2. Description: Carbon steel (ASTM A 216) split body, stainless steel ball and stem, PTFE seat.

2.3 BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. NIBCO INC.
      b. Conbraco Industries, Inc.
      c. Hammond Valve.
      d. Milwaukee Valve Company.
      e. DeZURIK.
   2. Description: Cast iron (ASTM A 126) or ductile iron (ASTM A 536) lug type body, suitable for bidirectional dead-end service at rated pressure without use of downstream flange, EPDM seat, one or two piece stainless steel stem, nickel-plated ductile iron disc.
   3. Standard: MSS SP-67, Type I.

B. Iron, Grooved-End Butterfly Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Victaulic Company.
      b. Kennedy Valve Company; a division of McWane, Inc.
      c. Tyco Fire Products LP.
   2. Description: Coated ductile iron body, EPDM seal, two-piece stainless steel stem, coated ductile iron disc.
   3. Standard: MSS SP-67, Type I.

2.4 CHECK VALVES

A. Bronze, Swing Check Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2.5 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine mating flange faces for damage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

D. Do not attempt to repair defective valves; replace with new valves.

2.6 INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chain wheels on operators for butterfly valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install valve tags. Comply with requirements in Section 22 05 53 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

2.7 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

2.8 VALVE SCHEDULE

A. Refer to piping system sections for valve schedules.

B. Coordinate Class or CWP rating with associated piping system rating.
   1. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
C. Valve Sizes: Same as upstream piping unless otherwise indicated.

END OF SECTION
SECTION 22 05 29 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Metal pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe positioning systems.
   7. Equipment supports.

B. Related Sections:
   1. Section 05 5000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.
   3. Section 01 8113 “Sustainability and LEED – NC V2009 Requirements” for sustainability requirements.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of the Valve and Fittings Industry Inc.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
   1. Trapeze pipe hangers.
   2. Equipment supports.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pre-galvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

B. Non-MFMA Manufacturer Metal Framing Systems:
   1. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
   3. Channels: Continuous slotted steel channel with inturned lips.
   4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

2.3 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.

B. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

C. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

D. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.4 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.5 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.6 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.
2.7 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications.
   2. Design Mix: 5,000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:
   1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.


H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:
1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: (12 inches) long and 0.048 inch thick.
   b. NPS 4: (12 inches) long and 0.06 inch thick.
   c. NPS 5 and NPS 6: (18 inches) long and 0.06 inch thick.
   d. NPS 8 to NPS 14: (24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: (24 inches) long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section 09 9123 “Interior Painting.”

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and attachments for general service applications.

F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS .
   2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
   3. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS , to allow off-center closure for hanger installation before pipe erection.
4. **Adjustable, Steel Band Hangers (MSS Type 7):** For suspension of noninsulated, stationary pipes NPS 1/2 to NPS.

5. **Adjustable Band Hangers (MSS Type 9):** For suspension of noninsulated, stationary pipes NPS 1/2 to NPS.

6. **Adjustable, Swivel-Ring Band Hangers (MSS Type 10):** For suspension of noninsulated, stationary pipes NPS 1/2 to NPS.

7. **Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11):** For suspension of noninsulated, stationary pipes NPS 1/2 to NPS.

8. **U-Bolts (MSS Type 24):** For support of heavy pipes NPS 1/2 to NPS 30.

9. **Clips (MSS Type 26):** For support of insulated pipes not subject to expansion or contraction.

10. **Pipe Saddle Supports (MSS Type 36):** For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.

11. **Pipe Stanchion Saddles (MSS Type 37):** For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.

12. **Adjustable Pipe Saddle Supports (MSS Type 38):** For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

13. **Single-Pipe Rolls (MSS Type 41):** For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.

**J. Vertical-Piping Clamps:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Extension Pipe or Riser Clamps (MSS Type 8):** For support of pipe risers NPS 3/4 to NPS.

2. **Carbon- or Alloy-Steel Riser Clamps (MSS Type 42):** For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

**K. Hanger-Rod Attachments:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Steel Turnbuckles (MSS Type 13):** For adjustment up to 6 inches for heavy loads.

2. **Steel Clevises (MSS Type 14):** For 120 to 450 deg F piping installations.

3. **Swivel Turnbuckles (MSS Type 15):** For use with MSS Type 11, split pipe rings.

4. **Malleable-Iron Sockets (MSS Type 16):** For attaching hanger rods to various types of building attachments.

5. **Steel Weldless Eye Nuts (MSS Type 17):** For 120 to 450 deg piping installations.

**L. Building Attachments:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Steel or Malleable Concrete Inserts (MSS Type 18):** For upper attachment to suspend pipe hangers from concrete ceiling.

2. **C-Clamps (MSS Type 23):** For structural shapes.

3. **Welded-Steel Brackets:** For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. **Light (MSS Type 31):** 750 lb.
   b. **Medium (MSS Type 32):** 1500 lb.
   c. **Heavy (MSS Type 33):** 3000 lb.

4. **Horizontal Travelers (MSS Type 58):** For supporting piping systems subject to linear horizontal movement where headroom is limited.

**M. Saddles and Shields:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Steel-Pipe-Covering Protection Saddles (MSS Type 39):** To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
   2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 in.
   3. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
   4. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
      a. Horizontal (MSS Type 54): Mounted horizontally.
      b. Vertical (MSS Type 55): Mounted vertically.
      c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

Q. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

R. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION
SECTION 22 05 48 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Elastomeric isolation pads.
   2. Housed-spring isolators.
   3. Restrained-spring isolators.
   5. Pipe-riser resilient supports.
   6. Elastomeric hangers.
   7. Restraint channel bracings.
   8. Restraint cables.
   10. Mechanical anchor bolts.
   11. Adhesive anchor bolts.

B. Related Requirements:
   1. Section 21 0548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
   2. Section 23 0548 "Vibration and Seismic Controls for HVAC" for devices for HVAC equipment and systems.

1.3 DEFINITIONS


1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
      b. Annotate to indicate application of each product submitted and compliance with requirements.
   3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:
1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment.

1.5 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
B. Qualification Data: For professional engineer and testing agency.
C. Welding certificates.
D. Field quality-control reports.

1.6 QUALITY ASSURANCE
A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPM number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
A. Seismic-Restraint Loading:
   1. Site Class as Defined in the IBC: D.
   2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III
      a. Component Importance Factor: 1.0.
      b. Component Response Modification Factor: \( a = 2.5 \) | \( R = 2.0 \)
      c. See structural sheet S0.02 and specification for other seismic design categories.

2.2 ELASTOMERIC ISOLATION PADS
A. Elastomeric Isolation Pads:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. California Dynamics Corporation.
   b. Isolation Technology, Inc.
   c. Mason Industries, Inc.
2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: elastomeric.
   a. Surface Pattern: Waffle pattern.
   b. Infused nonwoven cotton or synthetic fibers.

2.3 PIPE-RISER RESILIENT SUPPORT
A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch thick neoprene.
   1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
   2. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.4 RESTRAINT CHANNEL BRACINGS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line.
   2. Mason Industries.
   3. Unistrut.
   4. Tolco.
B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.5 RESTRAINT CABLES
A. Restraint Cables: ASTM A 603 galvanized, ASTM A 492 stainless-steel cables where exposed to weather or moisture. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.6 SEISMIC-RESTRAINT ACCESSORIES
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line
2. Mason Industries
3. Unistrut.
4. Tolco.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.7 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line
   2. Mason Industries
   3. Hilti, Inc.
   4. Kinetic Noise Control, Inc.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.8 ADHESIVE ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Hilti, Inc.
   2. Mason Industries
   3. Kinetic Noise Control, Inc.

B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 3000 "Cast-in-Place Concrete." and/or Section 03 3053 "Miscellaneous Cast-In-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 07 7200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

D. Equipment Restraints:
   1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
   2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

E. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 40 feet and longitudinal supports a maximum of 80 feet.
   3. Brace a change of direction longer than 12 feet.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.
G. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

K. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   5. Set anchors to manufacturer's recommended torque, using a torque wrench.
   6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 22 1116 "Domestic Water Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
   1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION
SECTION 22 05 53 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Stencils.
   5. Valve tags.
   6. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Kolbi Pipe Marker Co.
      c. Seton Identification Products.
   2. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
4. Background Color: Black.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Kolbi Pipe Marker Co.
   c. Seton Identification Products.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
2. Marking Services Inc.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.
D. Background Color: Yellow.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.


I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Kolbi Pipe Marker Co.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: Size letters according to ASME A13.1 for piping and at least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.4 STENCILS

A. Stencils for Piping:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brimar Industries, Inc.
      b. Kolbi Pipe Marker Co.
c. Marking Services Inc.

2. Lettering Size: Size letters according to ASME A13.1 for piping and at least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.


4. Stencil Paint: Exterior, gloss, acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

5. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

2.5 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Kolbi Pipe Marker Co.

B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link chain or beaded chain or S-hook.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Kolbi Pipe Marker Co.

B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
   1. Size: 3 by 5-1/4 inches minimum.
   2. Fasteners: Brass grommet and wire.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 09 9123 "Interior Painting."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.
   1. Identification Paint: Use for contrasting background.

C. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units and at each valve. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 25 feet (7.6 m) along each run.
   8. On both sides of walls or partitions penetrated by piping.

D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
E. **Pipe Label Color Schedule:**
   1. **Domestic Water Piping**
      a. Background: Safety green.
   2. **Sanitary Waste and Storm Drainage Piping:**
      a. Background Color: Safety black.

3.5 **VALVE-TAG INSTALLATION**

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. **Valve-Tag Application Schedule:** Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
   1. **Valve-Tag Size and Shape:**
   2. **Valve-Tag Colors:**
   3. **Letter Colors:**

3.6 **WARNING-TAG INSTALLATION**

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION
SECTION 22 07 16 - PLUMBING EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following plumbing equipment:
   1. Domestic water, hot-water pumps.

B. Related Sections:
   1. Section 22 07 19 "Plumbing Piping Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail removable insulation at equipment connections and access panels.
   3. Detail application of field-applied jackets.
   4. Detail application at linkages of control devices.
   5. Detail field application for each equipment type.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
   1. Sheet Form Insulation Materials: 12 inches square.
   2. Sheet Jacket Materials: 12 inches square.
   3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.
1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Equipment Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Industrial Insulation Group, LLC (IIG-LLC).
      b. Johns Manville
   2. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Mineral-Fiber, Preformed Pipe Insulation:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. ROXUL
      b. Knauf Insulation.
      c. Johns Manville.
   2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation.
      b. Johns Manville; a Berkshire Hathaway company.
      c. Knauf Insulation.
      d. Owens Corning.

2.2 INSULATING CEMENTS


2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
1. For indoor applications, use lagging adhesives that have a low VOC content for LEED IEQ Credit 4 requirement.
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over insulation.
3. Service Temperature Range: 0 to plus 180 deg F.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for equipment.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Metal Jacket:
   a. Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.

2.9 SECUREMENTS

A. Bands:
1. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal.
B. Wire: 0.080-inch nickel-copper alloy 0.062-inch soft-annealed, stainless steel 0.062-inch soft-annealed, galvanized steel.

2.10 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems and equipment to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg. F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg. F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item as specified in insulation system schedules.
C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
      a. For below ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
5. Handholes.
6. Cleanouts.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe, and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
   d. Do not over compress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.
C. Insulation Installation on Pumps:
   1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch- diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
   2. Fabricate boxes from aluminum, at least 0.060 inch thick.
   3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 INSTALLATION OF CALCIUM SILICATE INSULATION
A. Insulation Installation on Domestic Water Boiler Breechings:
   1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.
   2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
   3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION
A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 FIELD-APPLIED JACKET INSTALLATION
A. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.8 FINISHES
A. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL
A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
B. Perform tests and inspections.
C. Tests and Inspections:
1. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.
   1. Nominal density.

3.10 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Domestic water pump insulation shall be one of the following:
   1. Mineral-Fiber Blanket: 1 inch thick and 6-lb/cu. ft. nominal density.
   2. Mineral-Fiber Board: 1 inch thick and 6-lb/cu. ft. nominal density.

D. Domestic hot-water pump insulation shall be one of the following:
   1. Mineral-Fiber Blanket: 1 inch thick and 6-lb/cu. ft. nominal density.
   2. Mineral-Fiber Board: 1 inch thick and nominal density.

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:
   1. Aluminum, Smooth: 0.016 inch thick.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
   1. Aluminum, Smooth: 0.016 inch thick.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
   1. Aluminum, Smooth with: 0.032 inch thick.

END OF SECTION
SECTION 22 07 19 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following plumbing piping services:
   1. Domestic cold-water piping for acoustics in Ceiling (where require by Acoustic Engineer.)
   2. Domestic hot-water piping.
   3. Domestic recirculating hot-water piping.
   4. Industrial Water Piping cold-water piping for acoustics in Ceiling (where require by Acoustic Engineer.)
   5. Industrial Hot Water piping.
   6. Industrial Hot Water Return piping
   7. Roof drains and rainwater leaders.
   8. Supplies and drains for handicap-accessible lavatories and sinks.
   9. Sanitary piping for acoustics in Ceiling (where require by Acoustic Engineer.)
  10. Storm piping for acoustics in Ceiling (where require by Acoustic Engineer.)
  11. Lab Waste piping for acoustics in Ceiling (where require by Acoustic Engineer.)
  12. Process Vacuum piping for acoustics in Ceiling (where require by Acoustic Engineer.)
  13. Purified Water piping for acoustics in Ceiling (where require by Acoustic Engineer.)

B. Related Sections:
   1. Section 22 07 16 "Plumbing Equipment Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail insulation application at pipe expansion joints for each type of insulation.
   3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   4. Detail removable insulation at piping specialties, equipment connections, and access panels.
   5. Detail application of field-applied jackets.
   6. Detail application at linkages of control devices.
1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

C. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.
PART 2 - PRODUCTS

2.1 INSULATION MATERIALS


B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber, Preformed Pipe Insulation:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. ROXUL
      b. Knauf Insulation.
      c. Johns Manville
   2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Ramco Insulation, Inc.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

2.4 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Metal Jacket:
      a. Factory cut and rolled to size.
      b. Finish and thickness are indicated in field-applied jacket schedules.
      c. Factory-Fabricated Fitting Covers:
         1) Same material, finish, and thickness as jacket.
         2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
         7) Valve covers.
         8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 SECUREMENTS

A. Bands:
   1. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal.

B. Wire: 0.080-inch nickel-copper alloy 0.062-inch soft-annealed, stainless steel 0.062-inch soft-annealed, galvanized steel.

2.9 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Insul-Tect Products Co.
      b. Plumberex Specialty Products, Inc.
c. Truebro.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.
H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer’s recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
      a. For below-ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, according to insulation material manufacturer’s written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
   1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
   2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
   3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
   4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
   1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
   2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
   3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
   4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
   5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
   4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.7 FIELD-APPLIED JACKET INSTALLATION
A. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.8 FINISHES
A. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL
A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.
3.10 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   1. Drainage piping located in crawl spaces.
   2. Underground piping unless serving hot water system.
   3. Chrome-plated pipes and fittings unless there is a potential for personnel injury and serving hot water system.

C. Domestic Cold-Water and Industrial Cold Water:
   1. Refer to Acoustic Engineer requirements for insulation requirements.

D. Domestic Hot, Industrial Hot, Recirculated Hot Water and Recirculated Industrial Hot Water:
   1. All domestic hot water and hot recirculation pipe shall be insulated per Title 24 and CPC 2016, whichever is stringent.
   2. NPS 1-1/4 (DN 32) and Smaller: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
   3. NPS 1-1/2 (DN 40) and Larger: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2" thick.

E. Storm water and Overflow:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

F. Roof Drain and Overflow Drain Bodies:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

G. Sanitary and Storm Water in Ceiling:
   1. Refer to Acoustic Engineer requirements for insulation requirements.

H. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

I. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

J. Process Vacuum Piping:
   1. Refer to Acoustic Engineer requirements for insulation requirements.

K. Purified Water Piping:
   1. Refer to Acoustic Engineer requirements for insulation requirements.
3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
   1. None.
   2. Aluminum, Smooth: 0.016 inch thick.

D. Piping, Exposed:
   1. Aluminum, Smooth: 0.016 inch thick.

END OF SECTION
SECTION 220800 – COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1. RELATED DOCUMENTS

A. The General Conditions, Supplementary Conditions and Division 01 are fully applicable to this Section, as if repeated herein.

1.2. RELATED WORK SPECIFIED ELSEWHERE

A. Division 01, Section 01910, General Commissioning Requirements

B. All Division 22 Sections, and Division 23 and 25 Sections pertaining to BAS Controls for Plumbing Systems.

1.3. REFERENCES

A. USGBC:
   1. LEED v4.0 Reference Guide for Building Design and Construction:
      a. Energy and Atmosphere Prerequisite: Fundamental Commissioning and Verification.

B. California Energy Commission:
   1. Title 24, Part 6, 2016, Building Energy Efficiency Standards, Section 10-103 and Section 120.8-Building Commissioning

C. ASHRAE:
   1. ASHRAE Guideline 0-2013: The Commissioning Process

1.4. DEFINITIONS

A. Basis of Design (BOD): The documentation of design criteria and assumptions for systems, components, and methods chosen to meet the Owner’s Project Requirements and applicable regulatory requirements, standards, and guidelines. The document includes narrative descriptions of the systems to be commissioned. The BOD is prepared by the Design Professionals.

B. Building Automation System (BAS): The automated building system providing control and user interaction with select building systems, such as the HVAC, domestic hot water and lighting systems. Also, often referred to as building management system (BMS), energy management system (EMS), or an energy management and control system (EMCS).

C. Commissioning (Cx): A quality-focused process to verify and document that building systems are installed and perform as intended per the OPR, BOD and design documents.
D. Commissioning Authority (CxA): An independent agent hired directly by the Owner and not otherwise associated with the Design Professionals or the General Contractor. The CxA is the authority on commissioning results and other commissioning program elements completion, and assists the General Contractor with coordinating commissioning activities and witnesses the activities on behalf of the Owner.

E. Commissioning Issue: A condition that affects, prevents or inhibits commissioning, and must be resolved to complete the commissioning process.

F. Commissioning Issues & Recommendations Log (Cx Log): A log maintained by the CxA listing and describing all Cx issues and recommendations documented during the commissioning process, including providing the status, recommended action, contractor updates and resolution, and associated dates. All Cx issues require action, correction and closure.

G. Commissioning Report (Cx Report): The final report issued at the conclusion of the commissioning process. The report will include an executive summary abbreviating the outcome of the commissioning process and identifying all outstanding issues. The report also contains all commissioning documentation collected throughout all phases of the project.

H. Commissioning Plan (Cx Plan): A document that outlines the organization, coordination, and requirements of the commissioning process in more detail and contains project specific commissioning forms.

I. General Contractor (GC): The contractor directly contracted to the Owner with overall responsibility for the project and all commissioning activities described herein.

J. Commissioning Coordinator (CxC): Individual within the GC firm who plans, schedules, directs and coordinates all the Trade Subcontractor’s commissioning activities, and serves as the CxA’s single point of contact for all administrative, documentation and coordination functions.

K. Deferred Testing: Testing performed at a later time, due to partial occupancy, equipment, load, seasonal requirements, design or other site conditions that disallow the test from being performed prior to substantial completion.

L. Deficiency: A condition in the installation, function or performance of a component, equipment or system that is not in compliance with the contract documents and design. A deficiency will be considered a Cx issue and documented on the Cx Log.

M. Design Professional (DP): Architects, engineers and other consultants involved in the design of the project.

N. Functional Performance Test (FPT): A test of the dynamic function, operation and control of the equipment and systems to verify system performance to the fullest extent. Systems are tested under various operating modes and control sequences including failure modes. The FPTs are performed using manual (direct observation) or monitoring methods. The FPTs can include sequence of operation tests, performance tests, verification tests, integrated systems tests, and trend analysis.

O. HVAC&R: Heating, ventilation, air conditioning and refrigeration.

P. Installation Verification (IV): Field verification and documentation of proper installation of system equipment, assemblies and components, per design documents and manufacturer requirements. The IV process is typically complete when systems are ready for startup or operation. IV is organized and documented under the System Readiness Checklist (SRC) forms.
Q. Monitoring: The recording of parameters (temperature, flow, current, status, pressure, etc.) of equipment operation, which shall be completed using data-loggers or the trending capabilities of BAS or control systems.

R. Owner’s Project Requirements (OPR): A document describing the operational and functional requirements of a project, the expectations of how the facility will be used and operated, and the equipment and system expectations and requirements, as defined by the Owner. This document provides an explanation of the ideas, concepts, goals, success criteria, and supporting information for the project.

S. Percent Sampling: Witnessing the startup, checkout or testing of a selected fraction of the total number of identical or near-identical pieces of equipment or systems.

T. Pre-Functional Checks and Tests (PFCT): These are various checks and tests performed on a piece of equipment or system before, during, or after the initial startup and operation, but prior to the FPT phase. They are performed to confirm the system equipment and individual components were installed correctly and are working properly and meeting applicable performance requirements and specifications. They are all organized and documented under the SRC forms and are to be completed prior to FPTs.

U. Startup: Initial starting or activating of equipment usually performed by the Trade Subcontractor or the Manufacturer’s authorized representative.

V. Systems Manual: A manual that provides the operating staff the information needed to understand and optimally operate the commissioned systems. It expands upon the scope of traditional operating and maintenance documents and is compiled of multiple documents such as the final BOD, single line diagrams, and as-built controls drawings and sequences of operation.

W. System Readiness Checklist (SRC): A construction checklist, typically one or two pages, listing the necessary commissioning tasks and required documentation to verify a system is ready for FPTs, or system operation if no FPTs are performed. The tasks covered in the SRC include IV, Startup and PFCT, and the Trade Subcontractor completed forms for these tasks are attached to the specific SRC. The SRC must be completed and signed by the GC prior to conducting the FPTs.

X. TAB: Testing, Adjusting, and Balancing (TAB) work on the plumbing water systems to ensure design flow, pressure and temperature conditions are met. Performed by the TAB Trade Subcontractor.

Y. Trade Subcontractor: Typically, a subcontractor to the GC who provides and installs specific building components and systems and/or provides certain services.

Z. Trending: Monitoring using the BAS or a control system, to aid in functional testing and to verify system operation and performance under actual operating conditions.

AA. Warranty Phase: The phase of the project immediately after the initiation of the building equipment warranty which spans the entire length of the project warranty.

1.5. DESCRIPTION OF WORK

A. Systems and equipment to be commissioned:
   1. Domestic cold and hot water systems and controls.
   2. Pumping systems and controls, including booster, sump, and sewage ejector pumps.
3. Plumbing fixtures with automatic controls.
5. Water recovery and re-use systems.
6. Any BAS controls or monitoring for plumbing systems.

B. Process equipment are not included in the commissioning scope of work.

C. The work includes the completion and documentation of formal commissioning procedures by the GC and Trade Subcontractors.
   1. The GC and Trade Subcontractors shall provide the quality control for the installation, startup, checkout and testing of the systems. The commissioning process provides independent review throughout the process and qualitative functional performance testing in order to formally observe and document the quality control efforts are completed.
   2. Refer to Section 01910, General Commissioning Requirements for summary description of the general commissioning process and requirements.
   3. The Trade Subcontractors and the factory authorized service representatives shall be responsible for participation in the commissioning process as outlined in this specification and Section 01910, General Commissioning Requirements.

1.6. COMMISSIONING PROCESS

A. Submittal Reviews by the CxA
   1. The CxA will review pertinent Trade Subcontractor submittals for the appropriate systems in the commissioning scope, concurrently with the Design Professionals and will provide review comments to the Design Professionals.
   2. The GC shall provide a submittal log to the CxA for referencing the requested submittals to be reviewed by the CxA (for which the GC shall issue to the CxA concurrently with the submission to the Design Professionals). Alternatively, the GC shall include the CxA on the distribution of all Trade Subcontractor submittals issued to the Design Professionals, for systems applicable to this specification.
   3. The GC shall issue the requested submittals to the CxA for review at the same time they issue the submittals to the Design Professionals.
   4. The CxA will also use the information from the submittals to develop commissioning forms and test procedures.

B. Cx Plan and Form Development
   1. The CxA prepares a Preliminary Cx Plan either during the project final design phase or early construction phase. The Cx Plan provides guidance in the execution of the commissioning process during construction and will contain the project specific commissioning forms.
   2. Commissioning during construction begins with a kickoff meeting conducted by the CxA where the CxA reviews the commissioning process and responsibilities with the appropriate team members. The CxA presents the Preliminary Cx Plan and discusses the project specific requirements.
   3. The CxA develops the SRC forms, which list the commissioning tasks and the associated IV, Startup, and PFCT documentation required for each system and equipment to be commissioned.
   4. The CxA provides the SRC forms to the GC and Trade Subcontractors for review and comment.
   5. The CxC shall submit to the CxA, for review and approval, the representative blank IV, Startup, and PFCT forms and plans for completing all IV, Startup, and PFCT tasks, prior to conducting any of these tasks.
a. IV forms are to provide field verification and documentation of proper installation of system equipment, assemblies and components, typically completed prior to formal Startup. Where appropriate and approved by the CxA, these forms may be combined with the Startup or PFCT forms.
   1) The IV forms are a combination of Trade Subcontractor provided forms (which may include any applicable design drawings, floor plans, details, or single line diagrams that will be field verified) and the applicable equipment IV (pre-startup) checklists contained in the Manufacturer’s installation manuals.
   2) The Trade Subcontractors are to verify equipment installation per the Manufacturer’s guidelines and requirements, and thus are encouraged to use and complete any applicable equipment IV checklists contained in the Manufacturer’s installation manuals, in addition to any IV forms used by the Trade Subcontractors to verify system installation per design.

b. Startup forms consist of Manufacturer and/or Trade Subcontractor provided forms and plans used to document the completion of formal startup procedures and associated checks and verifications during the startup and initial operation. Where applicable, these forms shall include checks of the equipment internal / factory provided controls including sensors and control devices.

c. PFCT forms and plans are Trade Subcontractor provided forms and plans used to document the completion and results for the various checks and tests performed before, during, or after startup.

d. The CxA reviews the blank IV, Startup and PFCT forms and plans, and will issue any comments, which may include additions or changes to be made to the forms and plans, and/or supplemental forms may be issued by the CxA, where appropriate, to improve the forms and commissioning process.

6. The CxA will develop FPT procedures and forms, and provide the draft forms to the GC and Trade Subcontractors for review and comment.

7. The CxA will update and finalize the Cx Plan with equipment specific blank SRC, IV, PFCT and FPT forms.

C. System Readiness (Pre-Functional) Activities

1. Meetings will be conducted throughout construction with commissioning team members, as required, to plan, coordinate, and schedule commissioning activities, review documentation, and resolve Cx issues.

2. The Trade Subcontractors shall perform the IV, Startup and PFCT tasks for all systems and equipment (no sampling allowed), unless the contract or design documents allow for sampling of the pre-functional tests.
   a. In general, the GC and Trade Subcontractors should complete IV prior to Startup, but where appropriate and approved by the CxA, they can combine IV and Startup into one activity (and Startup is not performed if there are deficiencies identified from the IV).

3. The Trade Subcontractors and the CxC shall document completion of the IV, Startup and PFCT tasks on the IV, Startup, PFCT and SRC forms, and shall complete the SRC forms and attach the completed IV, Startup, and PFCT forms to the SRCs forms.
   a. The intent of the SRC forms is for the GC and Trade Subcontractors to certify that the plumbing systems, controls and instrumentation, equipment and assemblies have been installed, started, calibrated and are operating per the contract and design documents.

4. The CxA will review the completed IV, Startup, PFCT and SRC forms. The CxA will also perform various field observations and reviews, and witness a sample of the Startup and
PFCT activities (some PFCT witnessing may be performed as back-checks after PFCT tasks are completed).

a. The Trade Subcontractor shall resolve any IV and PFCT results deemed unacceptable by the CxA. And the Trade Subcontractor shall execute a new sample of the PFCT to be witnessed by the CxA. The CxA shall deem the PFCT acceptable after resolution of all issues and any witnessed sampling results in no issues.

5. The CxC shall submit all completed SRC forms to the CxA for review prior to conducting the FPTs. The CxA shall deem the SRCs acceptable after all SRC forms and supporting IV, Startup and PFCT forms are complete and any issues have been addressed.

D. Functional Performance Testing

1. FPTs are to test the dynamic function, performance and control of the equipment and systems under various modes of operation. These tests verify the correct implementation of the sequences of operation and the system performance meets the design criteria. The FPTs are performed using manual (direct observation) or monitoring methods. FPTs include the following types of tests, where applicable:

a. Sequence of Operation Tests.
   
   1) Sequence of operation tests are witnessed by the CxA for each unique sequence of operation but may not necessarily be repeated across identical systems, equipment or spaces, if the contractor has verified the same programmed sequence of operation code (as tested) has been programmed across multiple identical systems, equipment or spaces, based sample verification tests witnessed by the CxA (see below).

b. Verification Tests.
   
   1) Verification tests are often less detailed tests than the sequence of operation tests and are typically witnessed by the CxA at a higher sample rate. Examples of verification tests include:

   a) verifying the programmed sequence of operation code is the same as the as-tested code per the sequence of operation tests,
   b) verifying the alarm points are configured per the sequence of operation tests (without having to repeat the actual sequence tests),
   c) reviewing and confirming control point displays on system graphics and required setpoints (for example verifying the BAS VAV min, max cool, max heat airflow setpoints are correct per design),
   d) testing certain critical or important sequences with a higher sample rate across identical systems, equipment or spaces, beyond the individual sequence of operation tests.

c. Performance Tests.
   
   1) Performance tests are to be performed after the sequence of operation and verifications tests, and are focused on testing and verifying performance. Performance tests are typically witnessed by the CxA at a lower sample rate. Examples include:

   a) testing and measuring fixture hot water temperature and delivery time per design criteria,
   b) testing the DHW heater water flow and temperature performance at simulated high cooling load conditions per design.

d. Integrated Systems Tests.
1) Integrated systems tests verify the operation and performance of multiple systems together operating in a coordinated, stable and efficient manner. Often the integrated systems tests are combined with the performance tests.

e. Trend Analysis.

2. The CxA will develop FPT forms that contain:
   a. Specific step-by-step procedures to execute the test in a clear, sequential and repeatable format, including any control system point value or setpoint overrides required to simulate a test condition or sequence mode.
   b. The expected system response and acceptance criteria of proper performance with a Yes/No check box to allow for clearly marking whether or not proper performance of each part of the test was achieved.
   c. A section for recording actual system response, notes and comments.

3. Once the SRC forms are complete, the Trade Subcontractors shall execute the FPTs, with the FPTs witnessed by the CxA.
   a. The GC and Trade Subcontractors are responsible for ensuring all systems are installed, operating and performing per the requirements of the contract and design documents, and are ready for the FPTs.
   b. The Trade Subcontractors shall determine what level of pre-testing is appropriate in order to prepare for the CxA witnessed FPTs.
   c. The CxA recommends the Trade Sub-Contractors complete the Title 24 acceptance testing and forms (see paragraph f below) as part of the contractor’s pre-testing and readiness for the CxA witnessed FPTs.
   d. A percent sampling approach shall be used for executing the FPTs of identical systems and equipment. The approximate system sampling rates for the manual (direct observation) FPTs are defined in Part 3 of this specification and/or in the Cx Plan.
   e. The acceptance criteria for the FPT sampling shall be zero, meaning, any FPTs that do not pass shall require the Trade Subcontractor to resolve the issue for all applicable systems and equipment (even those specifically not in the original sample) and new sample rates selected for a re-test executed by the Trade Subcontractor and witnessed by the CxA. The CxA shall deem the FPTs acceptable after all FPTs, including re-tests, have passed and resolution of all issues completed.
   f. The CxA will document the results of all FPTs on the associated FPT forms created by the CxA, unless indicated otherwise on the FPTs, and excluding completion of the Title 24 Certificate of Acceptance forms.

   a. Completion of the Title 24 Certificate of Acceptance forms (contained in Appendix A of the Title 24, Part 6 Compliance Manual) is a contractor responsibility, not the CxA responsibility.
   b. The responsible Division 22, 23, 25 and 26 Trade Subcontractors are also responsible for providing qualified and certified “Field Technicians” (per Title 24, Part 6 requirements) to perform and document the results of the acceptance tests on the applicable Title 24, Part 6 Certificate of Acceptance forms.

4. The Cx Plan will define any required seasonal or deferred testing.

E. Cx Issues and Recommendations

1. Throughout the process, the CxA records Cx issues and recommendations on the Cx Log and distributes the Cx List to the team. The GC and Trade Subcontractors shall correct Cx issues and recheck or retest the system(s) without delay at no additional cost to the Owner. The CxA will verify the completion of the issues and recommendations, and make all amendments to the Cx Log.
F. Training Verification and Final Documentation

1. The GC shall submit a comprehensive Training Plan (with specific training agendas provided by the Trade Subcontractors) for review by the Design Professionals, CxA and Owner, prior to conducting any training. The Training Plan shall meet the specific requirements in the contract documents and specifications for each applicable system to be commissioned and the LEED Enhanced Commissioning requirements, and may include both operations and maintenance (O&M) staff training and building occupant training. The GC shall coordinate with the Owner and/or Owner’s Representatives, as needed, regarding any specific requirements for occupant training.

2. The CxA will verify completion of the training by witnessing some training sessions and receiving a copy of all training class sign-in sheets and any training materials / handouts, to be provided by the CxC or Trade Subcontractors.

3. The CxA will develop the Systems Manual (per the LEED requirements), including the current facility requirements, a preventative information and an ongoing Cx plan, with assistance from the GC and Trade Subcontractors.

4. The CxA will complete the Commissioning Report and all associated documentation for the Owner with assistance from the GC and Trade Subcontractors.

G. Post-Occupancy Warranty Phase Commissioning

1. The CxA will report any identified operational or performance issues (identified by the building O&M staff or warranty phase Cx activities) to the CxC via a Warranty Phase Cx Log for resolution by the GC and Trade Subcontractors during or prior to the end of the warranty period.

2. The Trade Subcontractors shall execute any defined seasonal or deferred FPTs, witnessed by the CxA.

3. The CxA may and analyze review trend data during the Warranty Phase and will report any identified issues and recommendations for system improvements from the trend analysis.

4. No later than either 10 months after substation completion or two months prior to the expiration of the first 12-month warranty period of building occupancy, the CxA will return to the facility to interview facility O&M staff, walk the facility and review systems operation and trend data where applicable. Key representatives from the GC and Trade Subcontractors shall attend a site walk-through and meeting, as determined by the CxA.

1.7. COMMISSIONING TEAM

A. The Commissioning Team is responsible for performing the process and achieving successful commissioning results. The Commissioning Team is comprised of the following:

1. Owner and Owner’s Representatives
2. Commissioning Authority (CxA).
3. Design Professionals
4. General Contractor (GC)
5. GC’s Commissioning Coordinator (CxC)
6. Trade Subcontractors responsible for systems covered in this section include:
   a. Plumbing Contractor
   b. BAS Controls Contractor (if applicable)
   c. TAB Contractor (if applicable)
   d. Water Recovery & Re-use System Specialist or Manufacturer’s Representative (if applicable)

7. Manufacturer Representatives supplying equipment, materials, components and controls for the systems to be commissioned.
1.8. RESPONSIBILITIES

A. General.
  1. The Commissioning Team and all others involved in the commissioning process shall follow the Commissioning Plan, attend the commissioning kickoff meeting, and attend additional commissioning meetings as necessary.

B. Commissioning Authority (CxA)
  1. See Section 01910, General Commissioning Requirements.

C. General Contractor:
  1. See Section 01910, General Commissioning Requirements.

D. Trade Subcontractors – General Requirements:
  1. Provide and submit for CxA review, the representative blank forms and plans for completing all IV, Startup, and PFCT tasks, including manufacturer’s installation checks and startup procedures. Electronic files are acceptable.
  2. Provide any equipment and construction submittals and shop drawings, including detailed sequences of operation, and any other requested contract documentation for systems to be commissioned, as requested by the CxA. Electronic files are acceptable.
  3. Attend commissioning meetings as directed by the CxA and GC’s CxC to facilitate the commissioning process.
  4. Assign personnel with expertise and authority to act on behalf of the Trade Subcontractor and schedule them to participate in and perform assigned commissioning tasks.
  5. Ensure that any required manufacturer factory tests are performed and provide the factory test data and results where required.
     a. Perform IV, Startup and PFCT tasks for all systems and equipment (no sampling), unless the contract or design documents allow for sampling of these tasks.
     b. Complete all IV, Startup and PFCT documentation clearly and legibly.
     c. Submit all completed IV, Startup and PFCT forms to the CxC and CxA, as part of completing the SRC forms, for review by the CxA.
  7. Provide a schedule and access for the CxA to witness any equipment Startup and PFCT tasks. Notify the CxC and CxA at least 10 days in advance of Startup and PFCT tasks.
  8. Ensure that any required manufacturer’s representative field tests and on-site IV, startup and checkout of selected equipment are performed per the contract documents. Provide completed manufacturer documentation and commissioning forms for these activities to the CxC.
  9. Address applicable Cx issues promptly. All IV, Startup and PFCT issues must be resolved before the FPTs can proceed.
 10. Assist the CxA in preparing the FPT procedures, clarifying the operation and control of commissioned equipment where the specifications, control drawings or equipment documentation are not sufficient for writing detailed testing procedures.
 11. Review the FPT procedures to ensure feasibility, safety and equipment protection, and provide necessary written alarm limits, setpoint changes and overrides to be used during the tests.
 12. Setup any additional control system software points, global commands, overrides of any sensor values or relays, and overrides of any setpoints or schedules, to simulate certain conditions and operating modes, in order to conduct the FPTs.
 13. Perform the FPTs, with the FPTs witnessed by the CxA. Provide at least 10 days advance notice to the CxC and CxA for scheduling the FPTs.
14. The Division 22, 23 and 25 Trade Subcontractors (Plumbing, Mechanical and BAS) are responsible for providing qualified and certified "Field Technicians" (per Title 24, Part 6 requirements, where applicable) to perform and document the results of the acceptance procedures (Acceptance Tests) on Certificate of Acceptance forms per Title 24, Part 6.
   a. The GC or the responsible Trade Subcontractor shall be the designated "Responsible Person" per Title 24, Part 6, for certification of the acceptance testing/verification on the Certificate of Acceptance forms (contained in Appendix A of the Title 24, Part 6 Compliance Manual).

15. Setup the BAS and any other control system trends and provide all requested Trend data for the FPTs and post-occupancy warranty phase commissioning review to the CxA.
   a. As an Owner approved alternative, the Trade Subcontractors may provide the CxA remote access to the BAS and any other control system, with the Owner's permission, which will allow the CxA to easily and directly download the trend data files.

16. Prepare a training agenda for each training class for the equipment and systems to be commissioned.

17. Coordinate with the GC and Owner to schedule and plan training. Execute training of Owner's personnel per approved training agenda and schedule. Provide copies of training class sign-in sheets and materials / handouts.

18. Prepare O&M Manuals according to the Contract Documents.

19. Assist the CxA in developing the Systems Manual, including providing as-built drawings, controls sequences, setpoints, single-line diagrams, etc., necessary for the Systems Manual.

E. Trade Subcontractors – Specific Plumbing System Requirements

1. In addition to the general Trade Subcontractor responsibilities outlined above, the Plumbing Trade Subcontractor responsibilities during commissioning shall include, but are not limited to:
   a. Provide approved submittals, including shop drawings, control drawings (showing all control points and sensors), points list and detailed sequences of operation for each piece of equipment and system to be controlled (inclusive of any local, stand-alone plumbing system controls). The control system diagrams shall show all control points, sensor locations, actuators, and controllers. The system sequence of operation shall fully describe their equipment components and functionality, including setpoints, failure modes and alarm functions. The detailed sequence of operation shall be provided regardless of the completeness and clarity of the sequences in the controls specification and/or drawings. Electronic files are acceptable.
   b. Provide a list of any test metering and sensors to be used for sensor and device calibration purposes. All test meter and sensors shall have been calibrated within a year and have calibration documentation.
   c. Submit a Pipe System Pressure Test Plan for all applicable plumbing systems (including water recovery and re-use), for review by the CxA, at least 4 weeks in advance of conducting any required tests. The Test Plan shall include the section of pipe to be tested, and the test methods, pressures and durations.
   d. Submit a Clean, Flush and Treatment Plan for all applicable plumbing systems (including water recovery and re-use), for review by the CxA, at least 4 weeks in advance of filling any plumbing hydronic systems. The Plan shall include the following:
      1) The intended minimum durations for all pipe cleaning and flushing, the associated disinfectants to be used and any applicable water treatment to be performed after the clean and flush.
e. For any applicable, dedicated Plumbing and Water Recovery / Re-use Control Systems (not part of the BAS or not plumbing equipment factory controls), submit representative blank forms for conducting any Controls IV and PFCT tasks to be conducted by the Trade Subcontractors, for review by the CxA, at least 4 weeks in advance of performing any Controls IV and PFCT tasks. The dedicated plumbing Control Systems IV and PFCT tasks forms shall include:

1) Installation verification checks of the control input and output points (sensors, actuators, relays, etc.) to verify all points have been installed per the points list and the physical installation of each point has been verified.
2) Point-to-point checks with the local controller display interface or graphics.
3) Sensor accuracy checks or calibration results:
   a) For analog input sensors that are factory calibrated (no field calibration is required per Specifications):
      i. The controller or control system program setup (point type, range/scale, etc.) shall be verified and recorded in the PFCT forms, and the sensor reading on the local controller display or graphics shall be recorded on the PFCT forms and shall be checked by verifying the sensor reading is within the expected range.
      ii. Sensor readings that are questionable or outside the expected range shall be checked using a hand-held sensor of equal accuracy.
   b) For sensors that require field calibration, follow the manufacturer requirements for calibration and record the calibration results in the PFCT forms, including any readings using a hand-held sensor of equal accuracy.
4) Actuator checks:
   a) At a minimum, all actuators shall be physically checked at commanded full open position (100% open), commanded half-open position (50% open) and commanded fully closed position (0% open).

f. For the BAS Controls IV and PFCT blank forms applicable to the plumbing systems, see Section 23 08 00.
g. For local plumbing equipment factory provided controls, the controls IV and PFCT forms can be included in the equipment specific IV and Startup forms (for example, as part of the plumbing contractor's or manufacturer representative's IV and Startup forms for the specific equipment inclusive of all local controls).
h. Submit the applicable completed dedicated plumbing Control System IV and PFCT forms for review by the CxA. After submitting the completed forms, the CxA may request onsite field review and back-check of the Controls IV and PFCTs, for an approximate 10% to 20% sample, to be selected by the CxA, or what can be accomplished in 1 full day.
i. Submit representative blank Plumbing Fixture Controls IV and PFCT forms, for review by the CxA, at least 4 weeks in advance of performing any IV.

1) The forms shall either contain floor plan based checklists or room by room table checklists that indicate completion of the IV and PFCT tasks for each plumbing fixture with automatic controls.
2) The intent of the forms is to:
   a) verify the installation of each fixture per design documents and manufacturer requirements,
   b) to verify any applicable automatic control settings have been adjusted and checked,
c) and to verify the operation and control has been tested.

3) The completed forms shall be attached to the corresponding SRC form.

j. Submit the completed Plumbing Fixture Controls IV and PFCT forms for review by the CxA. After submitting the completed forms, the CxA may request onsite field review and back-check, for an approximate 10% to 20% sample, to be selected by the CxA, or what can be accomplished in 1 full day.

k. Submit a Plumbing Water and Gas Meter IV and PFCT Plan with blank forms, for review by the CxA, at least 4 weeks in advance of conducting any IV. The Plan shall include the following items:

1) An outline of the plumbing meter IV per design and manufacturer requirements.
2) An outline of any plumbing meter pre-functional tests, required per specifications.
3) An outline of any plumbing meter pre-functional checks (e.g., meter programming checks, meter alarm configurations, etc.).
4) The representative blank IV and PFCT forms to be used.

I. Submit the completed Plumbing Meter IV and PFCT forms for review by the CxA. After submitting the completed forms, the CxA may request an onsite field review and back-check prior to conducting any FPTs.

m. Submit Plans for all other applicable plumbing systems pre-functional testing, per the project specifications, for review at least 4 weeks in advance of any required tests.

n. The Trade Subcontractors shall configure all plumbing system local equipment controls settings and/or control system settings, graphics and programming logic for the sequence of operations and associated setpoints, schedules, and alarms and verify the system operation, including the control loop tuning, prior to starting FPTs.

o. Prior to conducting the CxA witnessed FPTs, place the systems and controls into the operating modes intended for testing. Check all control system safety cutouts, alarms, and interlocks with other systems during each mode of operation prior to functional testing. Ensure all systems are operating and performing per the requirements of the contract and design documents, and have been pre-tested per the FPTs, and are ready for the CxA witnessed FPTs.

1) The Trade Subcontractors shall determine the appropriate level of pre-testing, to prepare for the CxA witnessed FPTs.

p. Participate in any applicable integrated whole building tests under emergency power. This test is initiated by disconnecting the utility power to the building, and it will involve multiple disciplines. All Trade Subcontractors shall participate in the FPTs as required for operation of the inter-related systems.

F. Trade Subcontractors – Specific BAS Control Requirements

1. See Section 230800 for the additional specific BAS Trade Subcontractor responsibilities, applicable for any BAS controls and monitoring for plumbing systems.

G. Trade Subcontractors – Specific TAB Requirements

1. See Section 230800 for the additional specific TAB Trade Subcontractor responsibilities, applicable for any TAB work for plumbing systems.

1.9. SUBMITTAL REQUIREMENTS FOR COMMISSIONING

A. Trade Subcontractor Commissioning Forms. The Trade Subcontractors shall submit to the CxA all applicable representative, blank forms and plans for IV, Startup and PFCT tasks for the project

Contra Costa Community College District
Contra Costa College
C-4016 New Science Building – DSA Increment 2

Section 220800 - Page 12 of 18
COMMISSIONING OF PLUMBING SYSTEMS
(as listed in 1.8 Trade Subcontractor Responsibilities), at least 4 weeks in advance of performing any of these tasks.

1. The draft SRC forms issued by the CxA will list the required IV, Startup and PFCT forms and plans, required for this project. The Trade Subcontractor shall review the draft SRCs to ensure all applicable, representative IV, Startup and PFCT forms and plans have been submitted for the CxA review.

2. The CxA will review these submitted commissioning forms including whether all project specific requirements are included.

3. The CxA may request additional data, changes and/or additions to these forms to confirm application prior to their use. If the Trade Subcontractor cannot submit sufficient forms, the CxA will provide forms based on the construction documents and specifications, manufacturer installation manuals and procedures, and/or industry standards or guidelines.

B. Training Agenda. The Trade Subcontractors shall develop a Training Agenda for each training session, per the requirements of the contract documents and specifications, and the LEED Enhanced Commissioning requirements, and may include both operations and maintenance (O&M) staff training and occupant training. The Training Agenda shall be included in the comprehensive Training Plan to be submitted by the GC for review by the CxA, Design Professionals, and/or the Owner (see Section 01910, General Commissioning Requirements). The GC and Trade Subcontractors shall coordinate to fully develop the comprehensive Training Plan with input from the Owner.

1. The Training Agenda for each training session shall include the following:
   a. equipment and/or systems covered;
   b. recommended attendees;
   c. proposed location;
   d. estimated duration;
   e. level of instruction to be provided and an outline of the training topics and subjects to be covered;
   f. list of any materials and handouts to be provided (or provided in advance);
   g. company to provide the training and the instructor's name and qualifications.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1. MEETINGS, SCHEDULING AND COORDINATION

A. See Section 01910 – General Commissioning Requirements.

3.2. DOCUMENTATION

A. The Trade Subcontractors have specific responsibilities for assisting in the development of equipment check, test and verification procedures and forms, and in performing and documenting commissioning tests, as directed by the CxC and as overseen by the CxA.

B. The Trade Subcontractors shall provide, wherever the Contract Documents require, system checks and testing, test reports, factory test data and reports, checklists, operational verifications and demonstration, etc., whether specified or not in the commissioning sections.
3.3. TEST EQUIPMENT

A. The Trade Subcontractor shall provide all test equipment in sufficient quantities to execute all Pre-Functional and Functional Performance Tests in an expedient fashion.

B. The test equipment shall be of industrial quality and suitable for testing and calibration with accuracy within the tolerance necessary to demonstrate system performance per the Contract Documents. If not otherwise specified, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5 degree F and a resolution to + or – 0.1 degree F.
2. Pressure sensors shall have an accuracy of + or – 2.0 percent of the value range being measured (not full range of meter) and have been calibrated within the last year.
3. Meters for measuring total dissolved solids (TDS) via electrical conductivity shall have an accuracy of + or – 2.0 percent and have been calibrated within the last year. Offsite lab testing of Water Recovery and Reuse System TDS levels is not required for testing and verification of installed TDS meters / sensors.

C. The test equipment shall have calibration certification per equipment manufacturer’s interval level or within one year if not otherwise specified. The calibration tags shall be affixed or certificates readily available for all test equipment.

3.4. SYSTEM READINESS: INSTALLATION VERIFICATION, STARTUP, PRE-FUNCTIONAL CHECKS & TESTS

A. The Trade Subcontractors shall conduct all startup procedures and tests without compromise to human or equipment safety. The GC and Trade Subcontractors shall be responsible for the liability and safety of conducting all startup, checks and tests.

B. The Trade Subcontractors shall clearly identify and list any issues and deficiencies resulting from the IV, Startup and PFCT tasks on the associated forms and immediately notify the CxA. The CxA will additionally document the issues on the Cx Log. Once issues and deficiencies are corrected and verified, the associated forms shall be updated and resubmitted, and any necessary field review, back-checks or re-tests witnessed by the CxA.

C. The CxC and Trade Subcontractors shall provide a minimum 10 days’ notice to the CxA for witnessing equipment Startup and PFCT tasks.

1. The sample rates for the CxA witnessing of plumbing system piping PFCT tasks and equipment startups, will be defined in the Cx Plan.

D. The GC and Trade Subcontractors shall ensure the completion of the SRC forms. Review and approval of the completed SRC forms by the CxA is required prior to conducting the FPTs.

3.5. FUNCTIONAL PERFORMANCE TESTS

A. The Trade Subcontractors shall perform all FPTs per the final FPT forms and complete the Title 24 Part 6 acceptance test requirements and Certificate of Acceptance forms, for all systems and equipment in the scope of commissioning. The FPTs shall be witnessed by the CxA. The Trade Subcontractors may need to complete off hours or weekend work in order to complete the FPTs.
B. The CxA will document all testing results on the FPT forms, not including the Title 24 Certificate of Acceptance forms. The completion of the Title 24 Certificate of Acceptance forms is a contractor responsibility.

C. As outlined in the Part 1 general commissioning process, a sampling approach shall be used for the FPTs of identical systems and equipment, using the sample rates as defined in the Cx Plan, with the specific systems and equipment selected by the CxA.

D. The Trade Subcontractors shall determine what level of pre-testing is appropriate in order to prepare for the CxA witnessed FPTs.

E. The CxC and Trade Subcontractors shall coordinate all FPTs with the CxA, and provide a minimum of 10 days' notice prior to conducting each test.

F. The GC and Trade Subcontractors shall have responsibility for the liability and safety of conducting all functional performance tests.

G. The Trade Subcontractor executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. to execute the test according to the test procedures.
   1. The Trade Subcontractors shall provide any necessary control system global or system level commands and setpoint adjustments necessary to conduct the testing as called out in the FPT procedures.

H. At completion of the test, the Trade Subcontractor shall return all affected building equipment and systems to their pre-test normal condition.

3.6. COMMISSIONING ISSUES, BACK-CHECKS AND RE-TESTS

A. When Cx issues are identified during testing, the CxA will discuss with the executing Trade Subcontractor and/or CxC and determine whether or not testing can proceed. The CxA may allow immediate correction of minor issues and deficiencies identified during testing. The Cx issue and any identified resolution will be documented on the test form in use in addition to the Cx Log.

B. The CxA will maintain and update the Cx Log, and document the issue resolution process. Copies will be distributed to the GC, Owner, and Trade Subcontractors as appropriate. The Trade Subcontractors shall provide updates and comments regarding issue status and resolution.

C. The Trade Subcontractors shall promptly correct all Cx issues. The responsible party shall correct the issue and inform the CxC and CxA of the resolution and completion date, and update the Cx Log accordingly (in the fields assigned for contractor updates).

D. The CxA will record completion on the Cx Log after a successful witnessed re-test, field review, back-check, verification obtained through appropriate documentation or photographs, or acceptance by the Design Professional or Owner. The CxC shall reschedule any applicable re-testing with the CxA and Trade Subcontractor. The Trade Subcontractor shall retest until achievement of passing performance or Owner acceptance of the noted issue.
   1. Where sampling is used for the PFCTs and FPTs, the results shall be deemed acceptable once all noted issues are resolved and any new sample tests or checks have passed.

E. Additional parties may require input during a dispute regarding a Cx issue. Regardless of the validity or responsibility of the issue, the CxA will have the final interpretive authority on Cx issues and the Owner will have the final approval authority.
F. The CxA may recommend solutions to Cx issues. However, the GC and Trade Subcontractors ultimately have the burden of responsibility to solve, correct and perform required retests.

G. Back-checks, Verifications and Re-testing:
   1. The CxA will witness one (1) re-test or will perform one (1) field back-check or verification of any Cx issue.
   2. The CxA’s total onsite time for re-test witnessing and field verification or back-check of Cx issues will be limited to no more than 2 work days (full 8-hour work days) for all applicable systems in the commissioning scope.
   3. The Owner may back-charge the GC for any additional fees from the CxA, resulting from any additional re-testing or field back-checks or verifications beyond this allocated total time.
   4. The CxC must provide a minimum 48 hours’ notice for scheduling any re-testing, though the CxA will attempt to accommodate a shorter timeframe if feasible.
   5. Any required re-testing shall not be considered a justified reason for a claim of delay or for a time extension.

H. For any re-testing required, the CxA will determine if the entire test must be re-tested or if it is acceptable to re-test specific portions of the test that had failed.

3.7. DEFERRED & SEASONAL TESTING

A. Before or during the end of the first year warranty period, the Trade Subcontractor shall complete any seasonal or deferred testing, required per the design specifications and as defined in the Cx Plan. The Trade Subcontractors shall complete tests in the same manner as all other commissioning tests, including CxA witnessing.

B. The CxC and Trade Subcontractor shall coordinate with CxA and Owner and schedule all deferred and seasonal testing.

3.8. TRAINING VERIFICATION

A. The CxC and Trade Subcontractors shall coordinate and schedule the training for the Owner’s facility and operations personnel, and building occupants. The CxC shall ensure that training is completed per the requirements of the contract documents and specifications.

B. Trade Subcontractors responsible for specific equipment and system training shall submit to the CxC, a written training agenda for each training class for the equipment and systems to be commissioned. The GC shall submit a comprehensive Training Plan, including the specific training agendas, to Owner, Design Professionals and CxA for review and approval. See also Section 01910, General Commissioning Requirements.

C. The CxA will review the Training Plans for commissioning verification prior to conducting the actual training.

D. For verification of actual training conducted, the CxC shall submit to CxA ‘attendee signed’ attendance sheets for each training session conducted and a copy of any final training presentations or handout materials.
3.9. COMMISSIONING ACCEPTANCE, CLOSE-OUT AND REPORTING

A. Completion of the main commissioning activities (system readiness checks, functional performance testing, and training) shall be accomplished as a prerequisite for substantial completion. Completion of any re-testing shall be completed prior to final acceptance of commissioning.

B. After completion of the main commissioning activities and following review of the completed commissioning documents, test results and the current Cx Log with the Owner, the Owner will indicate whether they accept completion of the project construction phase commissioning or if not, the requirements for acceptance. Upon Owner acceptance, any remaining open Cx issues will be transferred to the warranty phase Cx Log for tracking resolution and completion as part of the warranty phase commissioning.

C. Upon completion of all commissioning activities, the CxA will prepare and submit to the Owner a Cx Report detailing all completed commissioning activities and documentation. The CxC shall support this effort by providing all GC and Trade Subcontractor commissioning documentation.

D. The CxA will complete a Systems Manual for the systems and equipment commissioned, following the LEED requirements, with assistance provided by the CxC and Trade Subcontractors. The Systems Manual will provide the operating staff the information needed to understand and optimally operate the commissioned systems. It will also include the current facility requirements, O&M preventative maintenance information, and an ongoing commissioning plan. Per LEED enhanced commissioning requirements, the Systems Manual will contain the following sections and detail:

1. Current facility requirements including the final version of the BOD and systems narrative.
2. Final equipment list.
3. Systems single line diagrams or schematics.
4. Final as-built sequence of operations, control drawings (P&IDs), points lists and setpoints.
5. Additional operating instructions for key systems or integrated building systems such as water-side and air-side HVAC systems and controls, plumbing systems, lighting controls, etc.
6. Recommended schedule of major preventative maintenance requirements and frequency.
7. Ongoing Cx Plan
   a. Definition of the ongoing commissioning process, defined roles and responsibilities, a recommended schedule for recommissioning the systems;
   b. Recommended schedule for retesting of commissioned systems with blank test forms from the Final Commissioning Plan.
   c. Recommended schedule for calibrating sensors and actuators.

3.10. POST-OCCUPANCY WARRANTY PHASE COMMISSIONING

A. The Trade Subcontractors shall execute any defined seasonal or deferred FPTs, witnessed by the CxA.

B. The CxA may review BAS trend data during the Warranty Phase. The BAS Trade Contractor shall be responsible for providing post-occupancy trend data to the CxA.

C. The CxA will report any identified issues and recommendations to the CxC via a Warranty Phase Cx Log for review and resolution by the GC and Trade Subcontractors prior to the end of the warranty period, for any issues or recommendations identified either by the CxA or the Owner. The CxC shall work with the Trade Subcontractors and O&M staff to make corrections and adjustments as required to address the issues and recommendations.
D. Key representatives from the GC and Trade Subcontractors shall attend a near end of warranty commissioning review meeting, to be scheduled with the Owner’s facility staff and the CxA, no later than either 10 months after substation completion or two months prior to the expiration of the first 12-month warranty period of building occupancy.

1. During this meeting, the operation of the systems will be discussed with the Owner’s staff, the results of any commissioning trend analysis will be reviewed and the warranty phase Cx Log will be reviewed. If needed, a walk-through of the systems with the Owner’s staff will be conducted.

2. Next steps and actions items for any open Cx issues and recommendations will be discussed and documented via meeting minutes or a field report issued by the CxA. The intent is to resolve any open Cx issues prior to the end of the warranty phase.

E. After correcting noted Warranty Phase Cx issues, the CxC shall notify the CxA, and the CxA will back-check and verify resolution of the Cx issues and recommendations.

F. Issues identified during the warranty period will remain warranty phase Cx issues until satisfactory completion by Trade Subcontractors, even if the warranty period expires during the correction and back-check period.

END OF SECTION
SECTION 22 11 16 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.
   2. Section 22 11 13 "Facility Water Distribution Piping" for water-service piping and water meters outside the building from source to the point where water-service piping enters the building.

1.3 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.
   B. Field quality-control reports.

1.5 FIELD CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
   1. Notify Construction Manager no fewer than two days in advance of proposed interruption of water service.
   2. Do not interrupt water service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G. Plastic piping components shall be marked with "NSF-pw."
C. All materials that come into contact with potable water shall be lead free.
D. All materials specified in this section shall be manufactured in the United States.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) water tube, hard drawn temper.
B. Copper Tube: ASTM B 88, Type K (ASTM B 88M, Type A) water tube, annealed (hard drawn) temper.
D. Copper Unions:
   1. MSS SP-123.
   4. Solder-joint or threaded ends.
   5. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International.
      b. Grinnell Mechanical Products.
      c. Victaulic Company.
   7. Mechanical Couplings for Grooved-End Copper Tubing:
      a. Copper-tube dimensions and design similar to AWWA C606.
      b. EPDM-rubber gaskets suitable for hot and cold water.
      c. Bolts and nuts.
      d. Minimum Pressure Rating: 300 psig (2070 kPa).

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:
   1. AWWA C110/A21.10, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
   2. Full-face or ring type unless otherwise indicated.
B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
C. Solder Filler Metals: ASTM B 32, lead-free alloys.
D. Flux: ASTM B 813, water flushable.
E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
F. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.4 TRANSITION FITTINGS

A. General Requirements:
1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.
4. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Dresser, Inc.
   c. Romac Industries, Inc.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Flanges:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Watts; a Watts Water Technologies company.
      b. Wilkins.
      c. Zurn Industries, LLC.
   3. Factory-fabricated, bolted, companion-flange assembly.
   4. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
   5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
   6. 6" brass nipple.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 31 2000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 22 0519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 22 1119 "Domestic Water Piping Specialties."

D. Install shutoff valve immediately upstream of each dielectric fitting.
E. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 22.1119 "Domestic Water Piping Specialties."

F. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

G. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 22.0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

H. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

I. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

J. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

K. Install piping to permit valve servicing.

L. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and branch connections.

O. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

P. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 22.0519 "Meters and Gages for Plumbing Piping."

Q. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 22.1123 "Domestic Water Pumps."

R. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 22.0519 "Meters and Gages for Plumbing Piping."

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22.0517 "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22.0517 "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22.0518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

G. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

H. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. Fittings for NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.
   2. Fittings for NPS 2 (DN 50) and Larger: Sleeve-type coupling.

3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges nipples.

D. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices in Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger, support products, and installation in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   2. NPS 1 and NPS 1-1/2 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
   3. NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
   4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
   5. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
   6. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
   7. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

F. Install supports for vertical copper tubing every 10 feet (3 m).

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
   3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
   4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
   5. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
   6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
   7. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
   8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.

H. Install supports for vertical steel piping every 15 feet (4.5 m).

I. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
   3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
   4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
   5. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
   6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
   7. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
   8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.

3.7 CONNECTIONS
1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
4. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 22 0553 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Piping Inspections:
      a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
      b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
         1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
         2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
      c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
      d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
   2. Piping Tests:
      a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
      b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
      c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
      d. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
      e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
      f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.
3.10 ADJUSTING

A. Perform the following adjustments before operation:
   1. Close drain valves, hydrants, and hose bibbs.
   2. Open shutoff valves to fully open position.
   3. Open throttling valves to proper setting.
   4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
      a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
      b. Adjust calibrated balancing valves to flows indicated.
   5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
   7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
   8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Fill and isolate system according to either of the following:
         1) Fill system or part thereof with water/chlorine solution with at least 50 ppm (50 mg/L) of chlorine. Isolate with valves and allow to stand for 24 hours.
         2) Fill system or part thereof with water/chlorine solution with at least 200 ppm (200 mg/L) of chlorine. Isolate and allow to stand for three hours.
      c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
      d. Repeat procedures if biological examination shows contamination.
      e. Submit water samples in sterile bottles to authorities having jurisdiction.
   3. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   4. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Under-building-slab, domestic water, building-service piping, NPS 3(DN 80) and smaller, shall be one of the following:
   1. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A); wrought-copper, solder-joint fittings; and brazed joints.

E. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 (DN 100 to DN 200) and larger, shall be one of the following:
   1. Copper (hard drawn) tube, ASTM B 88, Type K (ASTM B 88M, Type A); wrought-copper, brazed joints.

F. Aboveground domestic water piping, NPS 2 (DN 50)-1/2 and smaller, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); wrought-copper, solder-joint fittings; and soldered joints.

G. Aboveground domestic water piping, NPS 2 (DN 50) and smaller, shall be:
   1. Hard copper tube, ASTM B 88, Type L wrought copper, solder-joint fittings; and soldered joints.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff Duty: Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
   2. Throttling Duty: Use ball or globe valves for piping NPS 2 (DN 50) and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

END OF SECTION
SECTION 22 11 18 - NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Pipes, tubes, and fittings.
   2. Piping specialties.
   3. Piping and tubing joining materials.
   4. Valves.
   5. Pressure regulators.
   7. Concrete bases.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:
   1. Piping and Valves: 100 psig minimum unless otherwise indicated.
   2. Service Regulators: 100 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: 0.5 psig.

C. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig but not more than 2 psig, and is reduced to secondary pressure of 0.25 psig or less.
1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Piping specialties.
   2. Corrugated, stainless-steel tubing with associated components.
   3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
   4. Pressure regulators. Indicate pressure ratings and capacities.
   5. Service meters. Indicate 100 psi capacities.
   6. Dielectric fittings.

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
   1. Shop Drawing Scale: 1/4 inch per foot.
   2. Detail mounting, supports, and valve arrangements for service meter assembly and pressure regulator assembly.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

C. Qualification Data: For qualified professional engineer.

D. Welding certificates.

E. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, “Structural Welding Code - Steel.”

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.
B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.9 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
   1. Notify Architect and/or Owner no fewer than 5 days in advance of proposed interruption of natural-gas service.
   2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 08 3113 "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.


4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

   b. End Connections: Threaded or butt welding to match pipe.
   c. Lapped Face: Not permitted underground.
   e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
5. **Protective Coating for Underground Piping:** Factory-applied, three-layer coating of epoxy, adhesive, and PE.
   a. **Joint Cover Kits:** Epoxy paint, adhesive, and heat-shrink PE sleeves.

B. **Corrugated, Stainless-Steel Tubing:** Comply with ANSI/IAS LC 1.
   1. **Tubing:** ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
   2. **Coating:** PE with flame retardant.
      a. **Surface-Burning Characteristics:** As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
         1) Flame-Spread Index: 25 or less.
         2) Smoke-Developed Index: 50 or less.
   3. **Fittings:** Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
   4. **Striker Plates:** Steel, designed to protect tubing from penetrations.
   5. **Manifolds:** Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
   6. **Operating-Pressure Rating:** 5 psig.

C. **PE Pipe:** ASTM D 2513, SDR 11.
   1. **PE Fittings:** ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
   2. **PE Transition Fittings:** Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   3. **Anodeless Service-Line Risers:** Factory fabricated and leak tested.
      a. **Underground Portion:** PE pipe complying with ASTM D 2513, SDR 11 inlet.
      b. **Casing:** Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering.
      c. **Aboveground Portion:** PE transition fitting.
      d. **Outlet:** threaded or flanged or suitable for welded connection.
      e. **Tracer wire connection.**
      f. **Ultraviolet shield.**
      g. **Stake supports:** with factory finish to match steel pipe casing or carrier pipe.
   4. **Transition Service-Line Risers:** Factory fabricated and leak tested.
      a. **Underground Portion:** PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
      b. **Outlets:** threaded or flanged or suitable for welded connection.
      c. **Bridging sleeve over mechanical coupling.**
      d. **Factory-connected anode.**
      e. **Tracer wire connection.**
      f. **Ultraviolet shield.**
      g. **Stake supports:** with factory finish to match steel pipe casing or carrier pipe.

2.2 **PIPING SPECIALTIES**

A. **Appliance Flexible Connectors:**
   1. **Indoor, Fixed-Appliance Flexible Connectors:** Comply with ANSI Z21.24.
   2. **Indoor, Movable-Appliance Flexible Connectors:** Comply with ANSI Z21.69.
   3. **Outdoor, Appliance Flexible Connectors:** Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.
1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. Basket Strainers:
1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

D. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.


2.4 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
1. CWP Rating: 125 psig.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Bronze Plug Valves: MSS SP-78.
2. Plug: Bronze.
4. Operator: Square head or lug type with tamperproof feature where indicated.
5. Pressure Class: 125 psig.
6. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.
1. Manufacturer: A.A. McDonald, Mueller Co., Xomox Corporation.
2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig (862 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Lubricated Plug Valves: MSS SP-78.
1. Manufacturer: A.A. McDonald, Mueller Co., Homestead Valve, Flowserve Corporation.
2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig (862 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Valve Boxes:
1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.
2.5 EARTHQUAKE VALVES

A. Earthquake Valves: Comply with ASCE 25,
   1. Manufacturer: Earthquake Valves, Vanguard Valves
   2. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   3. Maximum Operating Pressure: 5 psig.
   5. Nitrile-rubber valve washer.
   7. Threaded end connections complying with ASME B1.20.1.
   8. Wall mounting bracket with bubble level indicator.

2.6 PRESSURE REGULATORS

A. General Requirements:
   1. Single stage and suitable for natural gas.
   2. Steel jacket and corrosion-resistant components.
   3. Elevation compensator.
   4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.
   1. Manufacturer: American Meter, Fisher Control Valves, Invensys, Emerson, Maxitrol.
   2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
   5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
   6. Orifice: Aluminum; interchangeable.
   8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
   9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
   11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.

   1. Manufacturer: American Meter, Fisher Control Valves, Invensys, Emerson, Maxitrol.
   2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
   5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
   6. Orifice: Aluminum; interchangeable.
   8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
   9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 5 psig.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
   1. Manufacturer: A.Y. McDonald, Watts, Wilkins, Zurn.
   2. Description:
      b. Pressure Rating: 150 psig.
      c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
   1. Manufacturer: A.Y. McDonald, Watts, Wilkins, Zurn.
   2. Description:
      b. Factory-fabricated, bolted, companion-flange assembly.
      c. Pressure Rating: 150 psig.
      d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

2.8 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shut-off valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.
C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches below finished grade, or as required. Comply with requirements in Section 31 2000 "Earth Moving" for excavating, trenching, and backfilling.
   1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:
   1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
   2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
   3. Replace pipe having damaged PE coating with new pipe.

E. Copper Tubing with Protective Coating:
   1. Apply joint cover kits over tubing to cover, seal, and protect joints.
   2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

F. Install fittings for changes in direction and branch connections.

G. Install pressure gage downstream from each service regulator. Pressure gages are specified in Section 23 0519 "Meters and Gages for HVAC Piping."

3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
   1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
   1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
   2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
   3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
   4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
      a. Exception: Tubing passing through partitions or walls does not require striker barriers.
   5. Prohibited Locations:
      a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
      b. Do not install natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.
S. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gage downstream from each line regulator. Pressure gages are specified in Section 23 0519 "Meters and Gages for HVAC Piping."

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 0517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 0517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 0518 "Escutcheons for HVAC Piping."

Z. Install underground piping under the building to comply with NFPA 54 Section 7.1.6.2, using a PE pipe encased in a Schedule 40 PVC pipe.

3.5 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:
   1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
   2. Cut threads full and clean using sharp dies.
   3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
   4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.7 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 23 0548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements for pipe hangers and supports specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 1/2 and Smaller: Maximum span, 72 inches; minimum rod size, 3/8 inch.
2. NPS 3/4 and NPS 1: Maximum span, 96 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
5. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
6. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.8 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.
D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 PAINTING

A. Comply with requirements in Section 09 9113 "Exterior Painting" and Section 09 9123 "Interior Painting" for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Alkyd System: MPI EXT 5.1D.
      c. Topcoat: Exterior alkyd enamel flat.
      d. Color: Gray.

C. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.12 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be one of the following:
   1. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.
   2. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping; OR wrapped with tape.
B. Aboveground natural-gas piping shall be [one of] the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with wrought-steel fittings and welded joints.

3.13 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

   A. Aboveground, distribution piping shall be one of the following:
      1. Steel pipe with malleable-iron fittings and threaded joints.
      2. Steel pipe with wrought-steel fittings and welded joints.

3.14 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN 5 PSIG

   A. Aboveground, distribution piping shall be one of the following:
      1. Steel pipe with malleable-iron fittings and threaded joints.
      2. Steel pipe with steel welding fittings and welded joints.
      3. Drawn-temper copper tube with wrought-copper fittings and brazed joints.

3.15 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

   A. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter shall be one of the following:
      1. Bronze plug valve.

   B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be one of the following:
      1. Cast-iron, non lubricated plug valve.

   C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:
      1. Bronze plug valve.

   D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:
      1. Bronze plug valve.
      2. Cast-iron, non lubricated plug valve.

   E. Valves in branch piping for single appliance shall be one of the following:
      1. Bronze plug valve.

END OF SECTION
SECTION 22 11 19 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Backflow preventers.
   2. Water pressure-reducing valves.
   4. Temperature-actuated, water mixing valves.
   5. Strainers.
   6. Outlet boxes.
   8. Hose bibs.
   9. Wall hydrants.
   10. Drain valves.
   12. Trap-seal primer valves.
   13. Trap-seal primer systems.
   14. Flexible connectors.
   15. Water meters.

B. Related Requirements:
   1. Section 22 0519 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
   2. Section 22 1116 "Domestic Water Piping" for water meters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.
   1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.
PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61 Annex G and NSF 14.

B. All plumbing components including but not limited to valves, strainers, backflow preventers and other wetted parts shall be lead free.

C. Domestic water piping specialties shall be manufactured in the United States.

D. Backflow preventers shall be listed with the University of Southern California Foundation for Cross-Connection Control and Hydraulic Research

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Watts; a Watts Water Technologies company.
      b. Ames Co.
      c. Zurn Industries, LLC.
   3. Operation: Continuous-pressure applications.
   4. Pressure Loss: 12 psig maximum, through middle third of flow range.
   5. Size: See schedule.
   6. Design Flow Rate: See schedule.
   7. Selected Unit Flow Range Limits: See schedule.
   8. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
   9. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   10. Configuration: Designed for See plans and schedule flow.
   11. Accessories:
      a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
      b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

B. Double-Check, Detector-Assembly Backflow Preventers (For fire protection service piping only):
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Watts; a Watts Water Technologies company.
      b. Ames Co.
      c. Zurn Industries, LLC.
   2. Standard: ASSE 1048 and is FM Global approved or UL listed.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 5 psig maximum, through middle third of flow range.
5. Size: See schedule.
6. Design Flow Rate: See schedule.
7. Selected Unit Flow Range Limits: See schedule.
8. Pressure Loss at Design Flow Rate: See schedule.
9. Body: Cast iron with interior lining that complies with AWWA C550 or that is FDA approved.
11. Configuration: Designed for See plan drawings flow.
12. Accessories:
   a. Valves: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
   b. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

2.4 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Watts; a Watts Water Technologies company.
      b. Conbraco Industries, Inc.
      c. Zurn Industries, LLC.
   4. Size: See schedule.
   5. Design Flow Rate: See schedule.
   6. Design Inlet Pressure: See schedule.
   7. Design Outlet Pressure Setting: See schedule.
   8. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
   10. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

B. Water-Control Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CLA-VAL Automatic Control Valves.
      b. Watts; a Watts Water Technologies company.
      c. Zurn Industries, LLC.
   2. Description: Pilot-operated, diaphragm-type, single-seated, main water-control valve.
   3. Pressure Rating: Initial working pressure of 150 psig minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.
   4. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
      a. Size: See schedule.
      c. Trim: Stainless steel.
   6. Design Inlet Pressure: See schedule.
   7. Design Outlet Pressure Setting: See schedule.
   8. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
2.5 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. NIBCO INC.
      c. Watts; a Watts Water Technologies company.
      d. ITT Corporation.
      e. Taco Incorporated.
      f. Watts.
   2. Type: Ball valve with two readout ports and memory-setting indicator.
   3. Body: Brass or bronze.
   4. Size: Same as connected piping, but not larger than NPS 2.
   5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Cast-Iron Calibrated Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. NIBCO INC.
      c. Watts; a Watts Water Technologies company.
   2. Type: Adjustable with Y-pattern globe valve, two readout ports, and memory-setting indicator.
   3. Size: Same as connected piping, but not smaller than NPS 2-1/2.
   4. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

C. Memory-Stop Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      b. Milwaukee Valve Company.
      c. NIBCO INC.
   2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
   3. Pressure Rating: 400-psig minimum CWP.
   4. Size: NPS 2 or smaller.
   5. Body: Copper alloy.
   6. Port: Standard or full port.
   7. Ball: Chrome-plated brass.
   8. Seats and Seals: Replaceable.
   9. End Connections: Solder joint or threaded.

2.6 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Inc.
      b. Honeywell.
      c. Watts.
      d. Zurn.
      e. NIBCO INC.
4. Type: Thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
7. Accessories: Check stops on hot-and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 180 deg F.
9. Tempered-Water Design Flow Rate: see schedule.
10. Valve Finish: Rough bronze.

B. Primary, Thermostatic, Water Mixing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Leonard Valve Company.
   b. Powers.
   c. Symmons.
   d. Zurn.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Type: Exposed-mounted or Cabinet-type, thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 180°F.
9. Tempered-Water Design Flow Rate: see schedule.
10. Selected Valve Flow Rate at 45-psig Pressure Drop: see schedule.
11. Pressure Drop at Design Flow Rate: see schedule.
13. Piping Finish: Copper.

2.7 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers
1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
   a. Strainers NPS 2 and Smaller: 0.020 inch.
   b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
   c. Strainers NPS 5 and Larger: 0.10 inch.

2.8 OUTLET BOXES

A. Clothes Washer Outlet Boxes:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Oatey.
b. IPS Corporation.
c. LSP Products Group, Inc.
4. Faucet: Combination valved fitting or separate hot- and cold-water valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
5. Supply Shutoff Fittings: NPS 1/2 gate, globe, or ball valves and NPS 1/2 copper, water tubing.
6. Drain: NPS 2 standpipe and P-trap for direct waste connection to drainage piping.
7. Inlet Hoses: Two 60-inch-long, rubber household clothes washer inlet hoses with female, garden-hose-thread couplings. Include rubber washers.
8. Drain Hose: One 48-inch-long, rubber household clothes washer drain hose with hooked end.

B. Icemaker Outlet Boxes:
1. Mounting: Recessed.
3. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
4. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.9 HOSE BIBBS

A. Hose Bibbs:
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.10 WALL HYDRANTS

A. Non-freeze Wall Hydrants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Watts; a Watts Water Technologies company.
   c. Woodford Manufacturing Company.
   d. Zurn Industries, LLC.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.

B. Moderate-Climate Wall Hydrants >:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Watts; a Watts Water Technologies company.
   c. Woodford Manufacturing Company.
   d. Zurn Industries, LLC.
4. Operation: Loose key.
5. Inlet: NPS 3/4 or NPS 1.
6. Outlet:
   a. Concealed, with integral vacuum breaker or nonremovable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
   b. Garden-hose thread complying with ASME B1.20.7.
7. Box: Deep, flush mounted with cover.
8. Box and Cover Finish: Polished nickel bronze Retain "Outlet," "Box," and "Box and Cover Finish" subparagraphs above for concealed-outlet-type wall hydrants or "Outlet" and "Nozzle and Wall-Plate Finish" subparagraphs below for exposed-outlet-type wall hydrants.
9. Outlet:
   a. Concealed, with integral vacuum breaker or nonremovable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
   b. Garden-hose thread complying with ASME B1.20.7.
10. Nozzle and Wall-Plate Finish: Polished nickel bronze
11. Operating Key(s): Two with each wall hydrant.

C. Vacuum Breaker Wall Hydrants :
1. Standard: ASSE 1019, Type A or Type B.
2. Type: Freeze-resistant, automatic draining with integral air-inlet valve.
3. Classification: Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
5. Operation: Loose key.
6. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
7. Inlet: NPS 1/2 or NPS 3/4.
2.11 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:
2. Pressure Rating: 400-psig minimum CWP.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
8. Inlet: Threaded or solder joint.

2.12 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Precision Plumbing Products.
   b. Sioux Chief Manufacturing Company, Inc.
   c. Watts; a Watts Water Technologies company.
   d. Zurn Industries, LLC.
3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.13 TRAP-SEAL PRIMER DEVICE

A. Supply-Type, Trap-Seal Primer Device:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. MIFAB, Inc.
   b. Precision Plumbing Products.
   c. Zurn Industries, LLC.
5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.14 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Precision Plumbing Products.
   b. Zurn Industries, LLC.
2. Standard: ASSE 1044.
3. Piping: NPS 3/4, ASTM B 88, Type L; copper, water tubing.
5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.
   a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
7. Number Outlets: See plans and schedule. Insert number.

2.15 FLEXIBLE CONNECTORS
A. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
   2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
   3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

2.16 WATER METERS
A. Electromagnetic Water Meter

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
   1. Locate backflow preventers in same room as connected equipment or system.
   2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
   3. Do not install bypass piping around backflow preventers.
B. Install water regulators with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.
C. Install water-control valves with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.
D. Install balancing valves in locations where they can easily be adjusted.
E. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
   1. Install cabinet-type units recessed in or surface mounted on wall as specified.
F. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.
G. Install outlet boxes recessed in wall or surface mounted on wall. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 06 1000 "Rough Carpentry."

H. Install hose stations with check stops or shutoff valves on inlets and with thermometer on outlet.
   1. Install cabinet-type units recessed in or surface mounted on wall as specified. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 06 1000 "Rough Carpentry."

I. Set non-freeze, non-draining-type post hydrants in concrete or pavement.

J. Set freeze-resistant yard hydrants with riser pipe in concrete or pavement. Do not encase canister in concrete.

K. Install water-hammer arresters in water piping according to PDI-WH 201.

L. Install air vents at high points of water piping.

M. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

N. Install drainage-type, trap-seal primer valves as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

O. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

A. Comply with requirements for ground equipment in Section 26 0526 "Grounding and Bonding for Electrical Systems."

B. Fire-retardant-treated-wood blocking is specified in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" for electrical connections.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. Reduced-pressure-principle backflow preventers.
   2. Double-check, backflow-prevention assemblies.
   3. Dual-check-valve backflow preventers.
   4. Reduced-pressure-detector, fire-protection, backflow-preventer assemblies.
   5. Double-check, detector-assembly backflow preventers.
   7. Calibrated balancing valves.
   8. Primary, thermostatic, water mixing valves.
   9. Primary water tempering valves.
   10. Outlet boxes.
   11. Hose stations.
12. Supply-type, trap-seal primer valves.
13. Trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

FIELD QUALITY CONTROL

C. Perform the following tests and inspections:
1. Test each reduced-pressure-principle backflow preventer and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.

D. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION
SECTION 22 11 23.13 DOMESTIC - WATER PACKAGED BOOSTER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Multiplex, variable-speed booster pumps.

B. Related Sections:
   1. Section 22 30000 "Plumbing Equipment" for domestic-water circulation pumps.

1.3 DEFINITIONS

A. VFC: Variable-frequency controller(s).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For booster pumps. Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For booster pumps, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
1.6 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For booster pumps to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   B. ASME Compliance: Comply with ASME B31.9 for piping.
   C. UL Compliance for Packaged Pumping Systems:
      1. UL 508, "Industrial Control Equipment."
      2. UL 508A, "Industrial Control Panels."
      3. UL 778, "Motor-Operated Water Pumps."
   D. Booster pumps shall be listed and labeled as packaged pumping systems by testing agency acceptable to authorities having jurisdiction.

1.8 DELIVERY, STORAGE, AND HANDLING
   A. Retain protective coatings and flange’s protective covers during storage.

1.9 COORDINATION
   A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 MULTIPLEX, VARIABLE-SPEED BOOSTER PUMPS
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Bell & Gossett; a Xylem brand.
      2. Flowtherm.
      3. Grundfos Pumps Corporation U.S.A.
   B. Description: Factory-assembled, duplex, and -tested, fluid-handling system for domestic water, with pumps, piping, valves, specialties, and controls, and mounted on base.
   C. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for multiple-pump, variable-speed operation, with load control and protection functions.
   D. Base: Structural steel.
   E. Capacities and Characteristics:
      1. Refer to drawings.
2.2 MOTORS
A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine roughing-in for booster pumps to verify actual locations of piping connections before booster-pump installation.

3.2 INSTALLATION
A. Equipment Mounting:
   1. Install booster pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 3000 "Cast-in-Place Concrete." Section 03 3053 "Miscellaneous Cast-in-Place Concrete."
   2. Comply with requirements for vibration isolation and seismic control devices specified in Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
   3. Comply with requirements for vibration isolation devices specified in Section 22 0548.13 "Vibration Controls for Plumbing Piping and Equipment."

B. Support connected domestic-water piping so weight of piping is not supported by booster pumps.

3.3 CONNECTIONS
A. Comply with requirements for piping specified in Section 22 1116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect domestic-water piping to booster pumps. Install suction and discharge pipe equal to or greater than size of system suction and discharge headers or piping.
   1. Install shutoff valves on piping connections to booster-pump suction and discharge headers or piping. Install ball, butterfly, or gate valves same size as suction and discharge headers or piping. Comply with requirements for general-duty valves specified in Section 22 0523.12 "Ball Valves for Plumbing Piping," Section 22 0523.13 "Butterfly Valves for Plumbing Piping," and Section 22 0523.15 "Gate Valves for Plumbing Piping."
   2. Install union, flanged, or grooved-joint connections on suction and discharge headers or piping at connection to domestic-water piping. Comply with requirements for unions and flanges specified in Section 22 1116 "Domestic Water Piping."
   3. Install valved bypass, same size as and between piping, at connections to booster-pump suction and discharge headers or piping. Comply with requirements for domestic-water piping specified in Section 22 1116 "Domestic Water Piping."
   4. Install flexible connectors, same size as piping, on piping connections to booster-pump suction and discharge headers or piping. Comply with requirements for flexible connectors specified in Section 22 1116 "Domestic Water Piping."
   5. Install piping adjacent to booster pumps to allow service and maintenance.
3.4 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Perform visual and mechanical inspection.
   2. Leak Test: After installation, charge booster pump and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start booster pumps to confirm proper motor rotation and booster-pump operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Pumps and controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

A. Adjust booster pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust pressure set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting booster pump to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain booster pumps.

END OF SECTION
SECTION 22 13 16 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Pipe, tube, and fittings.
   2. Specialty pipe fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
B. Shop Drawings: For hubless drainage system. Include plans, elevations, sections, and details.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.
B. Field quality-control reports.

1.5 FIELD CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Construction Manager no fewer than two days in advance of proposed interruption of sanitary waste service.
   2. Do not proceed with interruption of sanitary waste service without Construction Manager's written permission.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.2 PIPING MATERIALS

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

C. Pipe, fittings and couplings shall be manufactured in the United States.

D. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute or receive prior approval of the engineer.

E. Manufacturers:
1. AB&I Foundry
2. Charlotte Pipe
3. Tyler Pipe
4. No other known equal

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service class(es).

B. Gaskets: ASTM C 564, rubber.

2.4 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Heavy-Duty, Hubless-Piping Couplings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ANACO-Husky.
   b. Mission Rubber Company, LLC; a division of MCP Industries.
   c. Tyler Pipe; a subsidiary of McWane Inc.
3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
2.5 GALVANIZED-STEEL PIPE AND FITTINGS

A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Standard Weight class. Include square-cut-grooved or threaded ends matching joining method.


C. Steel Pipe Pressure Fittings:

D. Cast-Iron Flanges: ASME B16.1, Class 125.
   1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
   2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

2.6 COPPER TUBE AND FITTINGS

A. Copper Type DWV Tube: ASTM B 306, drainage tube, drawn temper.

B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

C. Hard Copper Tube: ASTM B 88, Type L and Type M, water tube, drawn temper.

D. Soft Copper Tube: ASTM B 88, Type L, water tube, annealed temper.

E. Copper Pressure Fittings:
   2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

F. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

G. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Charlotte Pipe
   2. AB&I Foundry
   3. Tyler Pipe

H. PVC Schedule 40 solid wall pipe: ASTM D1784, ASTM D1785 and ASTM D2665, Class of 12454,
2.7 SPECIALTY PIPE FITTINGS

A. Transition Couplings:
1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
2. Shielded, Non-pressure Transition Couplings:
   b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
   c. End Connections: Same size as and compatible with pipes to be joined.
3. Pressure Transition Couplings:
   b. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
   c. Center-Sleeve Material: Stainless steel.
   d. Gasket Material: Natural or synthetic rubber.
   e. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:
1. Dielectric Flanges:
   a. Manufacturers:
      1) Watts; a Watts Water Technologies company.
      2) Wilkins.
      3) Zurn Industries, LLC.
   b. Description:
      1) Standard: ASSE 1079.
      2) Factory-fabricated, bolted, companion-flange assembly.
      3) Pressure Rating: 125 psig minimum at 180 deg F.
      4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
2. Dielectric Nipples:
   a. 6" brass nipple

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 31 2000 "Earth Moving."

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
   1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
   2. Install piping as indicated unless deviations to layout are approved on coordination drawings.
B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.
   1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
   2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.
      a. Straight tees, elbows, and crosses may be used on vent lines.
   3. Do not change direction of flow more than 90 degrees.
   4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
      a. Reducing size of waste piping in direction of flow is prohibited.

L. Lay buried building waste piping beginning at low point of each system.
   1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
   2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
   3. Maintain swab in piping and pull past each joint as completed.

M. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:
   1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 2 percent downward in direction of flow for piping NPS 4 and larger.
   3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

O. Install steel piping according to applicable plumbing code.

P. Install stainless-steel piping according to ASME A112.3.1 and applicable plumbing code.
Q. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

R. Install force mains at elevations indicated.

S. Plumbing Specialties:
   1. Install backwater valves in sanitary waster gravity-flow piping.
      a. Comply with requirements for backwater valves specified in Section 22 13 19 "Sanitary Waste Piping Specialties."
   2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.
      a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
      b. Comply with requirements for cleanouts specified in Section 22 13 19 "Sanitary Waste Piping Specialties."
   3. Install drains in sanitary waste gravity-flow piping.
      a. Comply with requirements for drains specified in Section 22 13 19 "Sanitary Waste Piping Specialties."

T. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

U. Install sleeves for piping penetrations of walls, ceilings, and floors.
   1. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs.
   1. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors.
   1. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

3.3 Joint Construction


C. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.
   1. Cut threads full and clean using sharp dies.
   2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
      a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
      b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
      c. Do not use pipe sections that have cracked or open welds.
E. Join stainless-steel pipe and fittings with gaskets according to ASME A112.3.1.

F. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

G. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

H. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in ODs.
   2. In Waste Drainage Piping: Shielded, non pressure transition couplings.
   4. In Underground Force Main Piping:
      a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
      b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:
   1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
   2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples.
   3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric nipples.
   4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

A. Comply with requirements in Section 22 0523.12 "Ball Valves for Plumbing Piping," Section 22 0523.13 "Butterfly Valves for Plumbing Piping," Section 22 0523.14 "Check Valves for Plumbing Piping," and Section 22 0523.15 "Gate Valves for Plumbing Piping" for general-duty valve installation requirements.

B. Shutoff Valves:
   1. Install shutoff valve on each sewage pump discharge.
   2. Install gate or full-port ball valve for piping NPS 2 and smaller.
   3. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment." Section 22 0548.13 "Vibration Controls for Plumbing Piping and Equipment."
1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
3. Vertical Piping: MSS Type 8 or Type 42, clamps.
4. Install individual, straight, horizontal piping runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls.
   Support pipe rolls on trapeze.
6. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
   4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
   5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
   6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6 and NPS 8: 12 feet with 3/4-inch rod.
   8. NPS 10 and NPS 12: 12 feet with 7/8-inch rod.

I. Install supports for vertical steel piping every 15 feet.

J. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 72 inches with 3/8-inch rod.
   2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   3. NPS 2-1/2: 108 inches with 1/2-inch rod.
   4. NPS 3 and NPS 5: 10 feet with 1/2-inch rod.
   5. NPS 6: 10 feet with 5/8-inch rod.
   6. NPS 8: 10 feet with 3/4-inch rod.

K. Install supports for vertical copper tubing every 10 feet.

L. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.
3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:
   1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
   5. Comply with requirements for cleanouts and drains specified in Section 22 1319 "Sanitary Waste Piping Specialties."
   6. Equipment: Connect waste piping as indicated.
      a. Provide shutoff valve if indicated and union for each connection.
      b. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:
   1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
      a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.
      a. Expose work that was covered or concealed before it was tested.
   3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.
      a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
      b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
      c. Inspect joints for leaks.
   4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.
      a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.
      b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
      c. Air pressure must remain constant without introducing additional air throughout period of inspection.
      d. Inspect plumbing fixture connections for gas and water leaks.
   5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   6. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Repair damage to adjacent materials caused by waste and vent piping installation.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 and smaller shall be any of the following:
   1. Hubless, cast-iron soil pipe and fittings; CISPI heavy-duty hubless-piping couplings; and coupled joints.
   2. Copper Type DWV tube, copper drainage fittings, and soldered joints.

C. Aboveground, soil and waste piping NPS 6 and larger shall be any of the following:
   1. Hubless, cast-iron soil pipe and fittings; CISPI heavy-duty hubless-piping couplings; and coupled joints.
D. Aboveground, vent piping NPS 4 and smaller shall be any of the following:
1. Hubless, cast-iron soil pipe and fittings; CISPI heavy-duty hubless-piping couplings; and coupled joints.
2. Copper Type DWV tube, copper drainage fittings, and soldered joints.

E. Aboveground, vent piping NPS 5 and larger shall be any of the following:
1. Hubless, cast-iron soil pipe and fittings; CISPI heavy-duty hubless-piping couplings; and coupled joints.

F. Underground, soil, waste, and vent piping NPS 4 and smaller shall be any of the following:
1. Virgin rigid PVC (polyvinyl chloride) vinyl compounds with a cell class of 12454 as identified in ASTM D1784. PVC Schedule 40 pipe shall be Iron Pipe Size (IPS) conforming to ASTM D1785 and ASTM D2665.

G. Underground, soil and waste piping NPS 5 and larger shall be any of the following:
1. Virgin rigid PVC (polyvinyl chloride) vinyl compounds with a cell class of 12454 as identified in ASTM D1784. PVC Schedule 40 pipe shall be Iron Pipe Size (IPS) conforming to ASTM D1785 and ASTM D2665.

END OF SECTION
SECTION 22 13 19 - SANITARY WASTE PIPING SPECIALITES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Backwater valves.
   2. Cleanouts.
   3. Roof flashing assemblies.
   4. Through-penetration firestop assemblies.
   5. Miscellaneous sanitary drainage piping specialties.

B. Related Requirements:
   1. Section 22 1423 "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.
   2. Section 33 4100 "Storm Utility Drainage Piping" for storm drainage piping and piping specialties outside the building.

1.3 DEFINITIONS


B. FOG: Fats, oils, and greases.

C. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, and accessories for the following:
   1. FOG disposal systems.

B. Shop Drawings:
   1. Show fabrication and installation details for frost-resistant vent terminals.
   2. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For FOG disposal systems, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Cultures: Provide 1-gal. bottles of bacteria culture recommended by manufacturer of FOG disposal systems equal to 200 percent of amount installed, but no fewer than 2 1-gal. bottles.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary waste piping specialty components.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing, and marked for intended location and application.

2.2 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Josam Company.
      c. Zurn Industries, LLC.
   3. Size: Same as connected piping.
   5. Cover: Cast iron with bolted or threaded access check valve.
   6. End Connections: Hub and spigot or hubless.
   7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
   8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.
   9. Refer to Schedules.
2.3 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Josam Company.
      c. Zurn Industries, LLC.
   2. Standard: ASME A112.36.2M.
   3. Size: Same as connected drainage piping
   4. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch or Hubless, cast-iron soil pipe test tee as required to match connected piping.
   5. Closure: Countersunk or raised-head, brass plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
   7. Refer to Schedules.

B. Cast-Iron Exposed Floor Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Josam Company.
      c. Zurn Industries, LLC.
   2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule threaded, adjustable housing cleanout.
   3. Size: Same as connected branch.
   4. Type: Cast-iron soil pipe with cast-iron ferrule, heavy-duty, adjustable housing threaded.
   5. Body or Ferrule: Cast iron.
   6. Clamping Device: As required.
   7. Outlet Connection: Inside calk, spigot or Threaded.
   8. Closure: Brass plug with tapered threads.
   9. Adjustable Housing Material: Cast iron with threads.
   11. Frame and Cover Shape: Round.
   12. Top Loading Classification: Heavy Duty.
   13. Riser: ASTM A 74, service class, cast-iron drainage pipe fitting and riser to cleanout.
   14. Refer to Schedules.

C. Cast-Iron Wall Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Josam Company.
      c. Zurn Industries, LLC.
   2. Standard: ASME A112.36.2M. Include wall access.
   3. Size: Same as connected drainage piping
   4. Body: Hub-and-spigot, cast-iron soil pipe T-branch or hubless, cast-iron soil pipe test tee as required to match connected piping.
   5. Closure Plug:
      a. Brass.
      b. Countersunk or raised head.
      c. Drilled and threaded for cover attachment screw.
      d. Size: Same as or not more than one size smaller than cleanout size.
      e. Refer to Schedules.

2.4 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Thaler Metal Industries Ltd.
      c. Zurn Industries, LLC.
   2. Description: Manufactured assembly made of 4.0-lb/sq. ft., 0.0625-inch-thick, lead flashing collar and skirt extending at least 6 inches from pipe, with galvanized-steel boot reinforcement and counterflash fitting.
      b. Low-Silhouette Vent Cap: With vandal-proof vent cap.
      c. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.5 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. 3M.
      b. Hilti.
      c. ProSet Systems Inc.
   3. Size: Same as connected soil, waste, or vent stack.
   4. Sleeve: Molded-PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.

2.6 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:
   1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564 rubber gaskets.
   2. Size: Same as connected waste piping with increaser fitting of size indicated.

B. Deep-Seal Traps:
   1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
   2. Size: Same as connected waste piping.
      a. NPS 2: 4-inch minimum water seal.
      b. NPS 2-1/2and Larger: 5-inch-minimum water seal.

C. Floor-Drain, Trap-Seal Primer Fittings:
   1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
   2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

D. Air-Gap Fittings:
1. **Standard:** ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. **Body:** Bronze or cast iron.
3. **Inlet:** Opening in top of body.
4. **Outlet:** Larger than inlet.
5. **Size:** Same as connected waste piping and with inlet large enough for associated indirect waste piping.
6. **Refer to Schedules.**

### E. Sleeve Flashing Device:
1. **Description:** Manufactured, cast-iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. **Size:** As required for close fit to riser or stack piping.

### F. Stack Flashing Fittings:
1. **Description:** Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. **Size:** Same as connected stack vent or vent stack.

### G. Vent Caps:
1. **Description:** Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. **Size:** Same as connected stack vent or vent stack.
3. **Refer to Schedules.**

---

**PART 3 - EXECUTION**

### 3.1 INSTALLATION

**A. Equipment Mounting:**
1. Install FOG disposal systems per code and manufacturer's requirements.
   a. Comply with requirements for equipment bases and foundations specified in Section 03 3000 "Cast-in-Place Concrete." Section 03 3053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration-isolation and seismic-control devices specified in Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
3. Comply with requirements for vibration-isolation devices specified in Section 22 0548.13 "Vibration Controls for Plumbing Piping and Equipment."

**B. Install backwater valves in building drain piping, where required.**
1. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

**C. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:**
1. **Size** same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. **Locate** at each change in direction of piping greater than 45 degrees.
3. **Locate** at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. **Locate** at base of each vertical soil and waste stack.
D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 07 6200 "Sheet Metal Flashing and Trim."

G. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 07 6200 "Sheet Metal Flashing and Trim."

H. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.
   1. Comply with requirements in Section 07 8413 "Penetration Firestopping."

I. Assemble open drain fittings and install with top of hub 2 inches above floor unless otherwise noted.

J. Install deep-seal traps on floor drains and other waste outlets, if indicated.

K. Install floor-drain, trap-seal primer fittings on inlet of all floor drains, floorsinks and hub drains.
   1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
   2. Size: Same as floor drain inlet.

L. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

M. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.

N. Install vent caps on each vent pipe passing through roof.

O. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

P. Assemble components of FOG disposal systems and install on floor.
   1. Install trap, vent, fresh-air inlet, and flow-control fitting according to authorities having jurisdiction.
   2. Install shelf fastened to reinforcement in wall construction and adjacent to unit, unless otherwise indicated.
   3. Install culture bottle, culture metering pump, timer, and control on shelf. Install tubing between culture bottle, metering pump, and chamber.

Q. Install wood-blocking reinforcement for wall-mounting-type specialties.

R. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 CONNECTIONS

A. Comply with requirements in Section 22 1316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to equipment to allow service and maintenance.

C. FOG Disposal Systems: Connect inlet and outlet to unit, connect flow-control fitting and fresh-air inlet piping to unit inlet piping, and connect vent piping between trap and media chamber. Connect electrical power.

D. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FLASHING INSTALLATION

A. Comply with requirements in Section 07 6200 "Sheet Metal Flashing and Trim."

B. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required.

C. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
   1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
   2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
   3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

D. Set flashing on floors and roofs in solid coating of bituminous cement.

E. Secure flashing into sleeve and specialty clamping ring or device.

F. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 07 6200 "Sheet Metal Flashing and Trim."

G. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. FOG disposal systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.
   1. Nameplates and signs are specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."
3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections, and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled FOG disposal systems and their installation, including piping and electrical connections, and to assist in testing.

B. Tests and Inspections:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain FOG disposal systems. Refer to Section 01 7900 "Demonstration and Training."

END OF SECTION
SECTION 22 13 19.13 - SANITARY DRAINS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section Includes:
   1. Floor drains.
   2. Floor Sinks.
   3. Trench drains.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES
A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.

2.2 FLOOR DRAINS
A. Cast-Iron Floor Drains:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Zurn Industries, LLC.
      c. Watts; a Watts Water Technologies company.
   2. Standard: ASME A112.6.3.
   5. Seepage Flange: Required.
   6. Anchor Flange: Required.
   7. Clamping Device: Required.
   8. Outlet: Bottom.
   11. Sediment Bucket: Not required.
   12. Top or Strainer Material: Nickel bronze.
   14. Top Shape: Round.
15. Dimensions of Top or Strainer: See schedule.
17. Funnel: Not required.
18. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
22. Garage Drains, refer to schedules.

2.3 FLOOR SINKS

A. Cast-Iron Floor Sinks:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Zurn Industries, LLC.
   c. Watts; a Watts Water Technologies company.
3. Pattern: Floor Sink.
5. Seepage Flange: Required.
6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom.
11. Sediment Bucket: Required.
12. Top or Strainer Material: Nickel bronze.
14. Top Shape: square.
15. Dimensions of Top or Strainer: See schedule.
17. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
18. Trap Material: Cast iron.
20. Trap Features: Trap-seal primer valve drain connection.

2.4 TRENCH DRAINS

A. Trench Drains:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Zurn Industries, LLC.
   c. Watts; a Watts Water Technologies company.
3. Material: Ductile or gray iron.
5. Clamping Device: Required.
6. Outlet: Bottom.
7. Grate Material: Ductile iron.
10. Top Loading Classification: Medium Duty.
11. Trap Material: Not required.
12. Trap Pattern: Not required.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
1. Position floor drains and floor sinks for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
3. Set with grates depressed according to the following drainage area radii:
   a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
   b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
   c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
   a. Maintain integrity of waterproof membranes where penetrated.
5. Install individual traps for floor drains and floor sinks, connected to sanitary building drain, unless otherwise indicated.

B. Install trench drains at low points of surface areas to be drained.
1. Set grates of drains flush with finished surface, unless otherwise indicated.

C. Install open drain fittings with top of hub 1 inch above floor.

3.2 CONNECTIONS

A. Comply with requirements in Section 22 1316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 22 1319 "Sanitary Waste Piping Specialties" for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.

C. Comply with requirements in Section 22 1323 "Sanitary Waste Interceptors" for grease interceptors, grease-removal devices, oil interceptors, sand interceptors, and solid interceptors.

D. Install piping adjacent to equipment to allow service and maintenance.

E. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
3.3 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION
SECTION 22 14 13 - STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Pipe, tube, and fittings.
   2. Specialty pipe fittings.

B. Related Sections:
   1. Section 33 4100 "Storm Utility Drainage Piping" for storm drainage piping outside the building.

1.3 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
   1. Storm Drainage Piping: 10-foot head of water.
   2. Storm Drainage, Force-Main Piping: 100 psig.

B. Seismic Performance: Storm drainage piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For storm drainage piping, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
1.7 PROJECT CONDITIONS

A. Interruption of Existing Storm-Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Construction Manager no fewer than two days in advance of proposed interruption of storm-drainage service.
   2. Do not proceed with interruption of storm-drainage service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Pipe, fittings and couplings shall be manufactured in the United States.

C. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute or receive prior approval of the engineer.

D. Manufacturers:
   1. AB&I Foundry
   2. Charlotte Pipe
   3. Tyler Pipe
   4. No other known equal

2.2 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service classes.

B. Gaskets: ASTM C 564, rubber.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Heavy-Duty, Hubless-Piping Couplings:
   1. Manufacturers:
      a. ANACO-Husky.
      b. Mission Rubber Company, LLC; a division of MCP Industries.
      c. Tyler Pipe; a subsidiary of McWane Inc.
   3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
2.4 PVC SCHEDULE 40 SOLID WALL PIPING AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Charlotte Pipe
   2. AB&I Foundry
   3. Tyler Pipe

B. PVC Schedule 40 solid wall pipe: ASTM D1784, ASTM D1785 and ASTM D2665, Class of 12454,

2.5 GALVANIZED-STEEL PIPE AND FITTINGS

A. Galvanized-Steel Pipe (where exposed to weather): ASTM A 53/A 53M, Type E, Standard Weight. Include square-cut-grooved or threaded ends matching joining method.


C. Steel-Pipe Pressure Fittings:

D. Cast-Iron Flanges: ASME B16.1, Class 125.
   1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
   2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

E. Grooved-Joint, Galvanized-Steel-Pipe Appurtenances:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International.
      b. Grinnell Mechanical Products.
      c. Victaulic Company.
   3. Grooved Mechanical Couplings for Galvanized-Steel Piping: ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber gasket suitable for hot and cold water; and bolts and nuts.

2.6 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.

B. Copper Drainage Fittings: ASME B16.23, cast-copper fittings or ASME B16.29, wrought-copper, solder-joint fittings.
C. **Hard Copper Tube:** ASTM B 88, Type L, water tube, drawn temper.

D. **Soft Copper Tube:** ASTM B 88, Type L, water tube, annealed temper.

E. **Copper Pressure Fittings:**
   1. **Copper Fittings:** ASME B16.18, cast-copper-alloy fittings or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
   2. **Copper Unions:** MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

F. **Copper Flanges:** ASME B16.24, Class 150, cast copper with solder-joint end.
   1. **Flange Gasket Materials:** ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
   2. **Flange Bolts and Nuts:** ASME B18.2.1, carbon steel unless otherwise indicated.

G. **Solder:** ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.7 **SPECIALTY PIPE FITTINGS**

A. **Transition Couplings:**
   1. **General Requirements:** Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections same size as and compatible with pipes to be joined.
   2. **Fitting-Type Transition Couplings:** Manufactured piping coupling or specified-piping-system fitting.
   3. **Shielded, Nonpressure Transition Couplings:**
      a. **Manufacturers:** Subject to compliance with requirements, provide products by the following:
         1) Mission Rubber Company, LLC; a division of MCP Industries.
         b. **Standard:** ASTM C 1460.
         c. **Description:** Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
   4. **Pressure Transition Couplings:**
      a. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
         1) Dresser, Inc.
         3) Romac Industries, Inc.
      b. **Standard:** AWWA C219.
      c. **Description:** Metal, sleeve-type couplings same size as, with pressure rating at least equal to and ends compatible with, pipes to be joined.
      d. **Center-Sleeve Material:** Stainless steel.
      e. **Gasket Material:** Natural or synthetic rubber.
      f. **Metal Component Finish:** Corrosion-resistant coating or material.

B. **Dielectric Fittings:**
   1. **General Requirements:** Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
   2. **Dielectric Flanges:**
      a. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
         1) Watts; a Watts Water Technologies company.
         2) Wilkins.
3) Zurn Industries, LLC.

b. Description:
   1) Standard: ASSE 1079.
   2) Factory-fabricated, bolted, companion-flange assembly.
   3) Pressure Rating: 150 psig.
   4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

3. Dielectric Nipples:
   a. Description:
      1) 6" brass nipple

**PART 3 - EXECUTION**

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 31 2000 "Earth Moving."

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for sags and bends.

I. Install piping to allow changes in direction and branch connections.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
L. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

M. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
   1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

O. Install steel piping according to applicable plumbing code.

P. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

Q. Install underground, ductile-iron, force-main piping according to AWWA C600. Install buried piping inside building between wall and floor penetrations and connection to storm sewer piping outside building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.

R. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."

S. Install force mains at elevations indicated.

T. Plumbing Specialties:
   1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Section 22 1423 "Storm Drainage Piping Specialties."
   2. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Section 22 1423 "Storm Drainage Piping Specialties."

U. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 0517 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 0517 "Sleeves and Sleeve Seals for Plumbing Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 0518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION


C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Join copper tube and fittings with soldered joints according to ASTM B 828 procedure. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

E. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fittings. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

F. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in ODs.
   2. In Drainage Piping: Shielded, non-pressure transition couplings.
   4. In Underground Force-Main Piping:
      a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
      b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:
   1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
   2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples.
   3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric nipples.
   4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Section 22 0523.12 "Ball Valves for Plumbing Piping," Section 22 0523.14 "Check Valves for Plumbing Piping," and Section 22 0523.15 "Gate Valves for Plumbing Piping."

B. Shutoff Valves: Install shutoff valve on each sump pump discharge.
   1. Install gate or full-port ball valve for piping NPS 2 and smaller.
   2. Install gate valve for piping NPS 2-1/2 and larger.

C. Check Valves: Install swing-check valve, between pump and shutoff valve, on each sump pump discharge.
3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 22.0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 22.0529 "Hangers and Supports for Plumbing Piping and Equipment."
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   3. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
   4. Vertical Piping: MSS Type 8 or Type 42, clamps.
   5. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
   6. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   7. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
   4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
   5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
   6. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6 and NPS 8: 12 feet with 3/4-inch rod.
   8. NPS 10 and NPS 12: 12 feet with 7/8-inch rod.

I. Install supports for vertical steel piping every 15 feet.

J. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 72 inches with 3/8-inch rod.
   2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   3. NPS 2-1/2: 108 inches with 1/2-inch rod.
4. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
5. NPS 6: 10 feet with 5/8-inch rod.
6. NPS 8: 10 feet with 3/4-inch rod.

K. Install supports for vertical copper tubing every 10 feet.

L. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.
   1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
   2. Comply with requirements for cleanouts and drains specified in Section 22 1423 "Storm Drainage Piping Specialties."

D. Connect force-main piping to the following:
   1. Storm Sewer: To exterior force main.
   2. Sump Pumps: To sump pump discharge.

E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

F. Make connections according to the following unless otherwise indicated:
   1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
   4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   5. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
   3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   4. Prepare reports for tests and required corrective action.

3.10 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground storm drainage piping NPS 6 and smaller shall be any of the following:
   1. Hubless, cast-iron soil pipe and fittings; CISPI, heavy-duty, hubless-piping couplings; and coupled joints.
   2. Galvanized-steel pipe, drainage fittings, and threaded joints.
   3. Copper DWV tube, copper drainage fittings, and soldered joints.

C. Aboveground, storm drainage piping NPS 8 and larger shall be any of the following:
1. Hubless, cast-iron soil pipe and fittings; CISPI, heavy-duty, hubless-piping couplings; and coupled joints.
2. Galvanized-steel pipe, drainage fittings, and threaded joints.
3. Copper DWV tube, copper drainage fittings, and soldered joints.

D. Underground storm drainage piping NPS 6 and smaller shall be any of the following:
   1. Virgin rigid PVC (polyvinyl chloride) vinyl compounds with a cell class of 12454 as identified in ASTM D1784. PVC Schedule 40 pipe shall be Iron Pipe Size (IPS) conforming to ASTM D1785 and ASTM D2665.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.END OF SECTION
SECTION 22 14 23 - STORM DRAINAGE PIPING AND SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Roof drains.
   2. Miscellaneous storm drainage piping specialties.
   3. Cleanouts.
   4. Through-penetration firestop assemblies.
   5. Flashing materials.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

A. Cast-Iron, Large-Sump, General-Purpose Roof Drains:
   1. Manufacturers:
      b. Watts; a Watts Water Technologies company.
      c. Zurn Industries, LLC.
      d. Refer to Schedules for Basis of Design.
   2. Standard: ASME A112.6.4, for general-purpose roof drains.
   5. Combination Flashing Ring and Gravel Stop: Required.
   7. Outlet: Bottom.
   8. Extension Collars: Not required.
  10. Expansion Joint: Not required.
  11. Sump Receiver Plate: Not required.
13. Perforated Gravel Guard: Not required.
15. Water Dam: 2 inches high. Water dam required on overflow drains only.

2.2 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Boots:
1. Description: Manufactured, ASTM A 48/A 48M, gray-iron casting, with strap or ears for attaching to building; NPS 4-outlet; and shop-applied bituminous coating.
2. Size: Inlet size to match downspout and NPS 4 outlet.

B. Conductor Nozzles:
1. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
2. Size: Same as connected conductor.

2.3 CLEANOUTS

A. Floor Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Watts; a Watts Water Technologies company.
   c. Zurn Industries, LLC.
   d. Refer to Schedules for Basis of Design.
2. Standard: ASME A112.36.2M, for adjustable housing cleanouts.
3. Size: Same as connected branch.
4. Type: Adjustable housing.
5. Body or Ferrule Material: Cast iron.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
11. Frame and Cover Shape: Round.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

B. Test Tees:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Watts; a Watts Water Technologies company.
   c. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301, for cleanout test tees.
3. Size: Same as connected drainage piping.
4. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or hub-less, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure Plug: Countersunk.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Wall Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Watts; a Watts Water Technologies company.
   c. Zurn Industries, LLC.
   d. Refer to Schedules for Basis of Design.
2. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
3. Size: Same as connected drainage piping.
4. Body Material: Hub-less, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure: Countersunk, plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.4 THROUGH- PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. 3M.
      b. Hilti, Inc.
      c. ProSet Systems Inc.
   2. Standard: ASTM E 814, for through-penetration firestop assemblies.
   4. Size: Same as connected pipe.
   5. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
   7. Special Coating: Corrosion resistant on interior of fittings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
   1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
   2. Install expansion joints, if indicated, in roof drain outlets.
   3. Position roof drains for easy access and maintenance.

B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.

C. Install downspout boots at grade with top 12 inches above grade unless otherwise indicated. Secure to building wall.

D. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
E. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
   1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
   3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate cleanouts at base of each vertical soil and waste stack.

F. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

G. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

H. Install test tees in vertical conductors and near floor.

I. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

J. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.

K. Install through-penetration firestop assemblies in plastic conductors at concrete floor penetrations.

L. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 1413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION
SECTION 22 30 00 - PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Air Source Heat Pump Water Heaters
B. Storage Tank Water Heaters
C. Circulator Pumps
D. Expansion Tanks

1.2 RELATED REQUIREMENTS

A. Section 26 27 26 - Wiring Devices: Electrical Characteristics and wiring connections
B. Section 22 05 01 - Plumbing General Requirements

1.3 REFERENCE STANDARDS

1.4 SUBMITTALS

A. See Section 01 33 00 - Submittal Procedures
B. Product Data:
   1. Provide dimension drawings of water heaters and heat pumps indicating components and connections to other equipment and piping.
   2. Indicate pump type, capacity, power requirements.
   3. Provide certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
   4. Provide electrical characteristics and connection requirements.
   5. Provide product cutsheets with the submitted product’s model number clearly identified.
C. Shop Drawings:
   1. Diagram power, signal, and control wiring.
D. Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.
E. Warranty: Submit manufacturer warranty and ensure forms have been completed in District’s name and registered with manufacturer.
1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Identification: Provide pumps with manufacturer's name, model number, and rating/capacity identified by permanently attached label.

C. Performance: Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, operate within 25 percent of midpoint of published maximum efficiency curve.

D. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.

E. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters and are based on specific units indicated. Other manufacturers' products complying with requirements may be considered. Refer to Division 1 Section "Substitutions."

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

G. ANSI Compliance: Provide gas water heaters that comply with ANSI standards for gas water heaters and related products and that bear AGA certification label.

H. ASME Compliance: Fabricate and label water heater, hot-water storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

I. ASHRAE Standards: Comply with performance efficiencies prescribed for the following:
   3. Regulatory Requirements: Fabricate and test steam condensate pumps to comply with HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation," and HI 1.6, "Centrifugal Pump Tests."

1.6 WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive City of other rights City may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of water heaters that fail in materials or workmanship within specified warranty period.

1.7 CERTIFICATIONS

A. Water Heaters: NSF approved.
1.8 DELIVERY, STORAGE, AND HANDLING

A. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

1.9 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

B. Provide five year manufacturer warranty for domestic water heaters.

PART 2 - PRODUCTS

2.1 AIR SOURCE HEAT PUMP WATER HEATER (HPWH)

A. Manufacturers:
   2. See Schedule for Basis for Design

B. Description: Heat Pump unit shall consist of compressor, condenser, evaporator coil, fan, hot water circulating pump, piping, and controls, factory assembled, charged, and tested. The heat pump shall contain the following components, and features:
   1. Cabinet: Shall be type 304 stainless steel. Supports, channels and beams shall also be constructed of type 304 stainless steel. Compartments shall have large access doors for servicing. Compressor and condenser shall be located in separate compartment from fan and evaporator for in-operation servicing. Base section under evaporator coil shall have stainless steel drip pan for condensate. Cabinet shall be designed for outdoor operation. Cabinet shall be insulated to prevent condensation from forming on exterior surfaces.
   2. Fan: The fan arrangement shall be draw-through design. Fans shall be centrifugal type, belt driven. Blower scroll construction shall be of 304 stainless steel with stainless steel fasteners. Blower wheel construction shall be galvanized steel. Motor shall be foot mounted to stainless steel mount having belt adjusting feature. Shaft bearing shall be pillow block type with easily accessible remote lubrication fittings.
   3. Evaporator Coil: Shall be constructed with aluminum waffle plate fins mechanically bonded to seamless copper tubing. All copper tube joints to be brazed with silver solder. Coils shall have corrosion inhibiting coated fins and type 304 stainless steel coil casings and drain pan.
   4. Refrigerant: Refrigerant shall be R134a.
   5. Expansion Valve: Valves shall be specifically designed for heat pump use with field adjustable superheat feature. Expansion valve shall have MOP (Maximum Operating Pressure) type power element to effectively limit saturated suction temperature to 18C (65F).
   6. Compressor: Hermetic scroll type by Copeland Corp., suitable for high temperature operation with R134a refrigerant. Compressor shall be furnished with rotolock backseating service valves for suction and discharge connections.
   7. Compressor Controls: Compressor controls/accessories must include the following:
      a. High Pressure Safety Switch
      b. Low Pressure Safety Switch
      c. Multi-function Phase Failure Relay
      d. Indicator Lights for:
         1) Power On
         2) Hot Water Demand
3) High Pressure Fail
4) Low Pressure Fail

8. Condenser: Stainless steel brazed plate vented double wall type. Single wall condenser construction shall not be allowed. UL Listed and suitable for high temperature operation with potable water.
   a. Refrigerant Accessories:
      1) Filter-Driers: Sweat connection type.
      2) Site Glass: Moisture indicating type.
      3) Liquid Line Service Valve: Bronze quarter turn type.
      4) Discharge Check Valve: Copper magnetic in-line type.
      5) Liquid Line Solenoid Valve: Electrically actuated.
      6) Compressor Crankcase Heater: Belly band type.

9. Anti-Short Cycle Control: Units shall be factory wired to allow a maximum of twelve compressor starts per hour to prevent compressor short cycling and allow time for suction and discharge pressures to equalize permitting the compressor to start in an unloaded condition.

10. Water Circulating Pumps: Shall be in-line all bronze or stainless steel body centrifugal type able to deliver rated flow against the external head shown on the drawings.

11. Controls: The heat pump unit shall be factory wired for fully automatic operation. Safeties shall include compressor and fan motor thermal overload protection, manual reset pressure-stats, anti-cycling compressor relays, plus standard items recommended by the equipment manufacturer.

12. Constant Leaving Water Temperature Control. Heat pump shall be factory equipped with electronic temperature control valve (e-TCV) which automatically maintains constant leaving water temperature regardless of entering water temperature. Leaving water temperature is set by the heat pump operator/user via a field adjustable electronic temperature controller.

2.2 DOMESTIC HOT WATER STORAGE TANK (HWST)

A. Manufacturers:
   1. PVI: www.pvi.com
   2. Hubbell Water Heaters: www.hubbellheaters.com

B. Type: ASME Rated Hot Water Storage Tank (HWST)
   1. See Schedule for Basis for Design

C. Factory-Installed Storage-Tank Appurtenances:
   1. Anode Rod: Replaceable magnesium.
   2. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
   3. Insulation: Comply with ASHRAE/IESNA 90.1.
   7. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
   8. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

D. Accessories:
   1. ANSI Z21.22, combination temperature and pressure relief valve
2. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE 90.1 or ASHRAE 90.2.
3. Provide electric resistance heating coil as indicated in the schedules.

E. Hot water output from tank shall pass through ASSE 1017 approved thermostatic master mixing valve before being sent to fixtures.

F. Provide factory diagram of dimensioned custom tank design indicating locations, size, and connection type of fittings within the tank.

G. Special Requirements: NSF 5 construction with legs for off-floor installation.

H. Capacity and Characteristics:
   1. Capacity:
      a. Refer to Schedules.
   2. Electrical Characteristics:
      a. Refer to Schedules.

2.3 CIRCULATOR PUMP (CP)

A. Manufacturers:
   1. Xylem: www.xyleminc.com
   2. Grundfos: www.us.grundfos.com
   3. ACT D’mand Kontrols Systems: www.gothotwater.com
   4. Bell & Gossett

B. Type: Electronically Commutated Permanent Magnet Motor
   1. See Schedule for Basis for Design

2.4 EXPANSION TANKS (ET)

A. Manufacturers:
   1. Amtrol: www.amtrol.com
   2. Wessels: www.westank.com

B. Type: ASME Rated Diaphragm Type
   1. Comply with ASME Section VIII, Division 1 Standards
   2. See Schedule for Basis for Design
   3. Pre-charged steel hydro-pneumatic tank with replaceable heavy-duty butyl bladder.
   4. NPT epoxy lined system connections and a 0.302”-32 charging valve connection (standard tire valve) to facilitate the on-site charging of the tank to meet system requirements. The tank must be constructed in accordance with most recent addendum of Section VIII Division 1 of the ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install plumbing equipment in accordance with manufacturer's instructions, as required by code, and complying with conditions of certification, if any.
B. Coordinate with plumbing piping and related piping work to achieve operating system.

C. Pumps:
1. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.
2. Install pumps with access for periodic maintenance, including removing motors, impellers, couplings, and accessories.
3. Support pumps and piping so weight of piping is not supported by pumps.
4. Suspend in-line pumps independent of piping. Use continuous-thread hanger rods and vibration isolation hangers of sufficient size to support pump weight. Fabricate brackets or supports as required.

3.2 CONNECTIONS

A. Pumps
1. Connect water distribution piping to pumps. Install suction and discharge pipe equal to or greater than size of pump nozzles.
2. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping.
3. Install pressure gages at suction and discharge of pumps. Install at integral pressure-gage tapping where provided or install pressure-gage connectors in suction and discharge piping around pumps.
4. Electrical wiring and connections are specified in Division 26.
5. Ground equipment.

3.3 FIELD QUALITY CONTROL

A. In addition to manufacturer's written installation and startup checks, perform the following:
1. Check for clear relief valve inlets, outlets, and drain piping.
2. Test operation of safety controls, relief valves, and devices.
3. Adjust operating controls.

B. Engage a factory-authorized service representative to train District's maintenance personnel to adjust, operate, and maintain fuel-fired, domestic water heaters. Refer to Division 1 Closeout Procedures/Demonstration and Training.

3.4 FIELD QUALITY CONTROL – HEAT PUMP WATER HEATER

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
1. Perform the following field tests and inspections:
   a. After installing air to water heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
   b. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Heat pumps will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

3.5 STARTUP SERVICE – HEAT PUMP WATER HEATER

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Inspect for visible damage to unit casing.
   3. Inspect for visible damage to compressor and coils.
   4. Inspect internal insulation.
   5. Verify that labels are clearly visible.
   6. Verify that clearances have been provided for servicing.
   7. Verify that controls are connected and operable.
   8. Adjust vibration isolators.
   9. Start unit according to manufacturer's written instructions.
   10. Complete startup sheets and attach copy with Contractor's startup report.
   11. Inspect and record performance of interlocks and protective devices; verify sequences.
   12. Operate unit for an initial period as recommended or required by manufacturer.
   13. Verify thermostat calibration.
   14. Inspect controls for correct sequencing of heating, refrigeration, and normal and emergency shutdown.

3.6 ADJUSTING - HEAT PUMP WATER HEATER

A. Adjust initial temperature set points.
   1. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
   2. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to four visits to Project during other-than-normal occupancy hours for this purpose.
      a. Factory representative must participate in the Commissioning process. A minimum of two of these visits shall be dedicated to supporting functional testing of the equipment in the Commissioning process.

3.7 DEMONSTRATION - HEAT PUMP WATER HEATER

A. Engage a factory-authorized service representative to train City's maintenance personnel to adjust, operate, and maintain air-source unitary heat pumps.

END OF SECTION
SECTION 22 36 00 - REVERSE OSMOSIS WATER EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the contract, including general and supplemental conditions, and Division 01 sections apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this project.

1.2 REVERSE OSMOSIS WATER EQUIPMENT AND RELATED ACCESSORIES

A. Pre-treatment
B. RO unit
C. DI mixed beds
D. Storage Tank
E. Distribution System.
F. UV light
G. Loop Cooler
H. Controls.

1.3 RELATED SECTIONS:

A. Section 220529 "Hangers and Supports for Plumbing Piping and Equipment".
B. Section 226700 "Processed Water Systems for Laboratory Facilities"

1.4 SUBMITTALS

A. Operation and Maintenance Data:
B. Submit operation and maintenance data under provisions of Division 01 Section "General Requirements" Paragraph 1.8.H "Operation and Maintenance Data"
C. Submit under provisions of Division 22 Section "Common Results for Plumbing - Review of Materials" and Division 01 Section "General Requirements."
   1. Pumps.
   2. Tanks.
   3. Controls.
D. Shop Drawings: Diagram power, signal, and control wiring.
E. ASME certificates.
F. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   1. The first names manufacturer and product is the basis of design. Other manufacturers and/or products are considered as substitutions.
   2. If an assembly is UL-listed, then the assembly UL-listing takes precedent over component-level UL-listings.

B. In lieu of listing by an approved testing laboratory, consideration will be given to certified test reports of an adequately equipped, recognized independent test laboratory competent to perform such testing indicating conformance to requirements of the applicable Underwriter's Laboratories, Inc. standards.

C. Unless otherwise approved by the Project Manager, the materials to be furnished under this specification shall be the standard products of manufacturers regularly engaged in the production of such equipment equal to or superior to the material specified, and shall be the manufacturer's latest standard design that complies with the specification requirements.

1.6 APPROVAL OF MATERIALS:

A. Division 01 Section "General Requirements" requirements for "Materials and Equipment" and "Submittals".

B. A complete list of materials and equipment proposed shall be submitted to the Project Manager for approval. The list shall include for each item: the manufacturer, the manufacturer's catalog number, type or class, the rating, capacity, size, etc.

C. Before installation of the equipment, the Subcontractor shall submit for approval detailed construction drawings for each item of fabricated equipment required for installation. Drawings shall be to scale and fully dimensioned and shall provide sufficient detail to clearly indicate the arrangement of equipment and its components.

D. Installation of approved substituted equipment is the Subcontractor's responsibility, and changes required to work included under other divisions for installations of approved substituted equipment must be made to the satisfaction of the District and without change in contract price. Approval by the District of substituted equipment and/or dimension drawings does not waive these requirements.

1.7 START-UP TRAINING

A. Assist District in preparing a formal training program for operating staff prior to the scheduled start-up date. The program will consist of the design, start-up, and operation of the mechanical, plumbing, fire protection, and building automation systems. Coordinate the training program
with the production of the operation and maintenance manuals. Provide indexed binder and training materials to each participant.

B. Provide 16 hours (unless specified otherwise) of on-site training in the operation and maintenance for installed system and major piece of equipment. Systems include boilers and heating hot water system, chillers and chilled water system, plumbing, fire protection, air supply and exhaust systems, air conditioning units, balancing, and Facilities Monitoring and Control System. Trainers shall be experienced, manufacturer-approved personnel.
   1. Schedule training for each system in advance with the District.
   2. Include travel, per diem and incidental costs for personnel under contract to the Subcontractor.
   3. Operations and Maintenance data to be available for training sessions.

C. Refer to Division 1 “Demonstration and Training” and “General Commissioning Requirements” for additional requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply for product selection:

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

C. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 REVERSE OSMOSIS WATER EQUIPMENT

A. Manufacturers:
   1. Evoqua/Siemens.
   2. Marlo.
   3. Culligan.
   4. Refer to Plumbing Schedules.
   5. Substitution: See Division 01 Section “General Requirements”.

2.3 PRE-TREATMENT:

B. Cartridge Filter: Cartridge filter housing with hydrophilic cartridges for water filtration, 10 micron filtration. Provide pressure gauges upstream and downstream of filter.

C. Water Softener: SDI service exchangeable softener cylinder sized for the design flowrate. Provide spare cylinder mounted adjacent to active unit.

D. Carbon Filter: SDI service exchangeable activated carbon cylinder sized for the design flowrate. Provide spare cylinder mounted adjacent to active unit.
2.3 REVERSE OSMOSIS UNIT:

A. General Description:
   1. Reverse Osmosis unit shall be skid mounted, fully automatic, single pass system. Unit shall be pre-assembled, prewired, single-point connection with fault alarm connection to BMS and hydrostatically and functionally tested at the factory. RO unit recovery shall be 75% or greater. Skid frame shall be epoxy coated and designed to provide easy access for servicing, maintenance and monitoring of operation.
   2. Frame shall be seismically designed and shall offer maximum support and protection for system components.
   3. RO pre-filter shall be 5 micron absolute, sized for maximum 3 psi pressure drop at maximum RO design flow.
   4. Valves:
      a. Automatic, pneumatically actuated, non-metallic or stainless steel valve shall be provided in feed line.
      b. High pressure valves, including pump discharge throttling valve, reject throttling needle valve and reject throttling valve shall be 316 stainless steel.
      c. Actuated flush valve shall be provided on a bypass around reject throttling valve.
      d. Sample valves shall be provided on feed, product and reject lines. Individual sample valve on product tubing of pressure vessel shall be provided for analyzing system.
      e. Reject and reject recycle needle valves shall be mounted in close proximity to their respective flowrate indicators for ease of field adjustment.
   5. Pressure gauges shall be furnished to monitor RO inlet pressure, pump suction pressure, membrane feed pressure, membrane reject pressure and RO product pressure.
   6. Piping shall be designed for minimal removal during membrane loading.
   7. Nozzles shall be provided for connection of temporary lines for cleaning and sanitizing RO membranes and vessels.
   8. Pump shall be 316 stainless steel.
   9. Control System: Microprocessor or PLC based control system shall monitor and control operation of system and communicate with pretreatment and distribution tank level as required. Control panel shall be NEMA 12, fully programmed and integrity tested at the factory prior to shipment. Control panel shall provide all power requirements to all integrated/interconnected components. Water purification system shall operate automatically and send fault alarm signal to BMS.
   10. Electrical: RO unit shall have a single point connection for 480V/3 phase power. Transformers for devices requiring other voltages shall be provided integral to the skid.

2.4 MIXED BED DI COLUMNS - EXCHANGABLE:

A. SDI service exchangeable, mixed resin, ion exchange beds. Beds contain 60% anion / 40% cation resin mixture, premium grade.

B. Provide conductivity indicator downstream of exchange cylinder.

C. Provide pressure gauges upstream and downstream of each exchange cylinder.

2.5 STORAGE TANK:

A. Cone bottom, cylindrical, atmospheric, closed top with flanged and covered 17" manway, high density cross linked polyethylene, indoor seismic restraints with sub micron hydrophobic vent filter and with return line plastic or stainless steel sprayball.
B. Tank shall be one-piece, seamless construction.

C. Tank shall be totally drainable.

D. Support shall be plastic or epoxy coated (2 coats) steel and that bottom of tank nozzle shall be at least 18" above finished floor.

E. Tank shall have pressure and vacuum relief to protect tank in the event of vent filter blockage or overfilling due to level controls malfunction.

2.6 RO DISTRIBUTION:

A. Skid mounted, fully automatic, pre-assembled, prewired, single-point connection with fault alarm connection to BMS and hydrostatically and functionally test at the factory. Skid frame shall be epoxy coated and designed to provide easy access for servicing, maintenance and monitoring of operation.

B. Multi-stage, stainless steel centrifugal, single mechanical seal, TEFC, 480V / 3 phase, VFD compatible. VFD shall be provided by Purified Water equipment vendor.

C. Provide flow meter for circulation line.

D. O distribution skid shall include UV light, loop cooler, control panel and final filters.

E. Control System: Microprocessor or PLC based control system shall monitor and control operation of system. Control panel shall be NEMA 12, fully programmed and integrity tested at the factory prior to shipment. Control panel shall provide all power requirements to all integrated/interconnected components. Water purification system shall operate automatically and send fault alarm signal to BMS. Control system should be BACNet compatible.

F. Electrical: RO distribution skid shall have a single point connection for 480V/3 phase power. Transformers for devices requiring other voltages shall be provided integral to the skid.

2.7 UV LIGHT:

A. Inline, 254 nm bacterial reduction, 316L stainless steel wetted surface electropolished to 15 Ra surface finish and passivated.

B. Accessories: Two (2) “S” pattern light traps, one (1) each for inlet and outlet.

C. Instrumentation: Temperature sensor with shutdown interlock, local alarm and dry contacts, LED indicator, elapsed running time meter, remote start/stop capability.

D. Electrical: 120V / 1 phase.

2.8 LOOP COOLER:

A. Sanitary, double tube sheet, shell and tube heat exchanger.

B. Shell side shall be chilled water.
C. Control shall be manual.
D. Provide temperature gauge on chilled water return line.
E. Provide pressure relief valve on chilled water line at exchanger for thermal expansion relief.
F. Provide globe valve on outlet of chilled water.
G. Controls are not required.

PART 3 - EXECUTION

3.1 HOLD AND INSPECTION
A. Refer to provisions of Division 01 Section “Special Procedures” for hold points for inspection, witnessing testing, etc.

3.2 INSTALLATION
A. Install equipment per manufacturer’s requirements. Drawings show general piping arrangement only. Refer to installation requirements in other Division Sections.
B. All equipment shall be furnished by one manufacturer.
C. Install concrete housekeeping pad under all equipment.

3.3 FIELD QUALITY CONTROL
A. Prior to operation, clean and test RO piping in accordance with specification section 220813.
B. Repair or replace RO piping as required to eliminate leaks and retest to demonstrate compliance.
C. Cap and seal ends of piping when not connected to mechanical equipment.

3.4 START UP
A. Engage a factory-authorized representative to provide start-up and ensure proper system operation.
B. Refer to Division 1 “Demonstration and Training” and “General Commissioning Requirements” for additional requirements.

3.5 WARRANTY
A. Provide 5-year manufacturer’s warranty.
B. DEMONSTRATION
C. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain laboratory vacuum equipment. Minimum 2 hours on-site demonstration required. Refer to Closeout Procedures.

D. Refer to Division 1 “Demonstration and Training” and “General Commissioning Requirements” for additional requirements.

END OF SECTION
SECTION 22 42 00 – PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Water closets.
   2. Urinals.
   3. Lavatories.
   4. Sinks.
   5. Showers.
   6. Drinking Fountains.

B. Related Requirements:
   1. Section 01 81 13 “Sustainable Design Requirements” for additional Leadership in Energy and Environmental Design (LEED®) certification-related references, definitions, documentation requirements, action plans, meetings, and performance requirements of products and systems.
   2. Section 22 11 16 “Domestic Water Piping”.
   3. Section 22 13 16 “Sanitary Waste and Vent Piping”.

1.3 DEFINITIONS

A. Effective Flush Volume: Average of two reduced flushes and one full flush per fixture.

B. Remote Water Closet: Located more than 30 feet (9.1 m) from other drain line connections or fixture and where less than 1.5 drainage fixture units are upstream of the drain line connection.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, clearances, and finishes.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant's review.
   2. A completed Green Building Material Certification Form (GBMCF), as specified in Section 01 81 13 Information to be supplied for this form shall include:
a. List of all adhesives and sealants installed on the project, within the LEED boundary that were included in the contract.
b. Cost breakdowns for the materials included in the Contractor or sub-contractor's work. Cost breakdowns shall include total cost plus itemized material costs.
c. A total estimated weight (lbs.) value of the material applied within the LEED project boundary.
d. IEQ credit 4, Low Emitting Materials: The VOC content in g/L or applicable certification label for each adhesives, sealants, coatings, paints, etc. per respective LEED requirement.

3. GBMCF Back-Up Documentation: These documents are used to validate the information provided on the GBMCF (except cost data). For each material listed on the GBMCF, provide documentation to certify the material's attributes, as applicable:
   a. IEQ credit 4, Low Emitting Materials: VOC content or applicable certification label proof in the form of a cutsheet, MSDS, or letter from the manufacturer.
   b. Product cut sheets for materials appearing in the GBMCF. Cut sheets shall be submitted with the Contractor or sub-contractor's stamp, as confirmation that the submitted products are the products installed on the Project.

4. Contractor is required to collect all LEED submittal documentation from the project's subcontractors and assemble into one (1) package per Section or trade, on the GBMCF provided, for review by the Sustainability Consultant. Submit GBMCF and Back-Up Documentation within 30 days of awarded contract. Incomplete or inaccurate LEED submittals may be used as the basis for rejecting the submitted products or assemblies.

C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.
   1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than one of each type.
   2. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed, but no fewer than one of each type.
   3. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed, but no fewer than one of each type.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Materials:
   1. Vitreous china fixtures shall be of highest quality, non-absorbent, hard-burned, and vitrified throughout.
2. Enameled ware shall be quality cast iron of uniform thickness and density, glazed to uniform depth and high gloss rubbed smooth, without chips or flaws, craze, or cracks, and completely acid resisting.

3. Stainless steel fixtures shall be 302/304 types of non-corrosive steel, 18 gage (1.20 mm) self rim for cabinet sinks, 14 gage (2.0 mm) for free standing compartment type sinks. Sink material shall have satin finish and cover corners, with faucet holes punched to match specified faucet fitting.

4. Precast receptors and shower basins shall be ["terrazzo" concrete][molded "stone" inert base and plasticizer][stainless steel][built up base and tile]. Receptor and basin colors shall be standard colors unless otherwise noted. Assembly of drain to waste piping shall be made from floor level on which basin or receptor is installed.

5. Insulation for traps and supplies shall be molded closed cell vinyl insulation and shall meet ASTM E84 for flame and smoke spread. Insulation shall be vandal resistant.

B. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 WATER CLOSETS

A. All water closet and flushometer combinations shall have a Maximum Performance Test (MaP) score of 800 or greater when the flushometer is tested with the water closet.

B. Mounting Height: Handicapped/elderly according to ICC/ANSI A117.1.

C. Wall Hung or Floor Mounted:

1. Fixture: white vitreous china, siphon jet, elongated bowl, 1.28 gal (4.8 L) per flush, NPS 1-1/2 (DN 40) top inlet spud.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Zurn Industries, LLC.
      2) Kohler Co.
      3) TOTO USA, INC.

2. Flushometer Valve: chrome plated exposed sensor activated diaphragm flushometer, brass body with corrosion resistant components, integral check stop and backflow preventer, 125 psig (860 kPa) minimum pressure rating.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Sloan Valve Company.
      2) American Standard
      3) Zurn Industries, LLC.
      4) TOTO USA, INC.
   b. Standard: ASSE 1037.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1) Bemis Manufacturing Company.
   2) Church Seats; Bemis Manufacturing Company.
   3) Olsonite Seat Co.
   4) American Standard.
   5) Kohler Co.
   6) TOTO USA Inc.


4. Water Closet Carrier: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

a. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1) Zurn Industries, LLC.
   2) J.R. Smith
   3) MIFDA

b. Standard: ASME A112.6.1M.

2.3 LAVATORIES

A. Mounting Height: Handicapped/elderly according to ICC/ANSI A117.1.

B. Wall Mounted:
   1. Fixture: white vitreous china, oval 20-1/2" x 18-1/4", one hole top faucet punching.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) American Standard America.
         2) Kohler Co.
         3) Zurn Industries, LLC.
   2. Faucet: automatic type, battery powered, electronic sensor operated, mixing, solid brass valve, rigid spout with aerator. Maximum flow rate: 0.5 gpm (1.5 L/min). Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Delta
         2) Chicago Faucets; Geberit Company.
         3) American Standard
         4) Kohler Co.
         5) Sloan Valve Company.
         6) Speakman Company.
   3. Type II Lavatory Carrier:
2.4 SINKS

A. Mounting Height: Handicapped/elderly according to ICC/ANSI A117.1.

B. Service Basin, floor mounted:

1. Fixture: white terrazzo, square 24" x 24" (610 x 610 mm), height of 10 inches (255 mm), rim guard on front top surface, grid type drain with NPS 3 (DN 80) outlet, mounted flush to wall.

   a. Manufacturers: Subject to compliance with requirements, provide products by the following:

      1) Florestone Products Co., Inc.
      2) Fiat Products Co.
      3) Acorn Engineering Company.


2. Faucet: manual type, two-lever handle, cross four arm; rigid solid brass spout with wall brace. Maximum flow rate: 2.2 gpm (8.3 L/min). Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor. Include hose thread spout and vacuum breaker.

   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

      1) Bradley Corporation.
      2) Speakman Company.
      3) T & S Brass and Bronze Works, Inc.
      4) Chicago Faucets; Geberit Company.


3. Type II Sink Carrier:

   a. Manufacturers: Subject to compliance with requirements, provide products by the following:
2) Watts; a Watts Water Technologies company.
3) Zurn Industries, LLC.
4) MIFAB

b. Standard: ASME A112.6.1M.

4. **Supply Fittings**: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange, chrome-plated-brass supply stops, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

5. **Waste Fittings**: grid type with NPS 1-1/2 (DN 40) offset and straight tailpiece, chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated, brass or steel wall flange.

6. **Grout**: hydraulic cement, nonshrink, premixed, post-hardening and volume-adjusting, dry 5000 psi (34.5 MPa) 28 day compressive strength
   a. Standard: ASTM C 1107/C 1107M, Grade B.

2.5 **DRINKING FOUNTAINS**

A. **Wall-mounted**:

1. **Fixture**: stainless steel rectangular receptor with wall plate behind fountain, two bubblers with adjustable stream regulator, 0.5 gpm, vandal resistant, push button control, grid type drain with NPS 1-1/4 (DN 32) outlet, chrome-plated brass P-trap and waste fitting, NPS 3/8 (DN 10) supply with shutoff valve, with bottle filler.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Elkay Manufacturing Co.
      2) Oasis International.
      3) Stern-Williams Co., Inc.

2. **Type I Water Cooler Carrier**:
   a. Manufacturers: Subject to compliance with requirements, provide products by the following:
      2) Josam.
      3) Watts; a Watts Water Technologies company.
   b. Standard: ASME A112.6.1M.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before installation.

B. Examine walls and floors for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General:

1. Install level and plumb according to roughing-in drawings.
2. Install accessible fixtures at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.
3. Install fresh batteries in battery-powered, electronic-sensor mechanisms.
4. Install according to manufacturer’s instructions.

B. Water-Closet Installation:

1. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
2. Support Installation:
   a. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
   b. Use carrier supports with waste-fitting assembly and seal.
   c. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.
3. Flushometer-Valve Installation:
   a. Install flushometer-valve, water-supply fitting on each supply to each water closet.
   b. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
   c. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
   d. Install actuators in locations that are easy for people with disabilities to reach.
4. Install toilet seats on water closets.

C. Lavatory Installation:

1. Install supports, affixed to building substrate, for wall-mounted lavatories.
2. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 22 07 19 "Plumbing Piping Insulation."

D. Sink Installation:

1. Install supports, affixed to building substrate, for wall-hung sinks.
2. Set floor-mounted sinks in leveling bed of cement grout.
3. Install water-supply piping with stop on each supply to each sink faucet.
a. Exception: Use ball valves if supply stops are not specified. Comply with valve requirements specified in Section 22 05 23 "General Duty Valves for Plumbing Piping".
b. Install stops in locations where they can be easily reached for operation.

E. Drinking Fountain Installation:
   1. Install recessed drinking fountains secured to blocking in wall construction.
   2. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
   3. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 22 05 23 "General Duty Valves for Plumbing Piping".
   4. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

F. Wall Flange and Escutcheon Installation:
   1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
   2. Install deep-pattern escutcheons if required to conceal protruding fittings.
   3. Comply with escutcheon requirements specified in Division 22.

G. Joint Sealing:
   1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
   2. Match sealant color to water-closet color.
   3. Comply with sealant requirements specified in Division 07.

3.3 CONNECTIONS
A. Connect fixtures with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.
B. Comply with water piping requirements specified in Section 22 11 16 "Domestic Water Piping."
C. Comply with soil and waste piping requirements specified in Section 22 13 16 "Sanitary Waste and Vent Piping."
D. Where installing piping adjacent to fixtures, allow space for service and maintenance.

3.4 ADJUSTING
A. Operate and adjust fixtures and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
B. Adjust water pressure at flushometer valves to produce proper flow.
C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.
3.5 CLEANING AND PROTECTION

A. Clean fixtures and fittings with manufacturers’ recommended cleaning methods and materials.

B. After installation and prior to occupancy, install protective covering for installed fixtures and fittings. Remove protection once Certificate of Occupancy is obtained.

C. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION
SECTION 22 45 00 - EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Emergency showers.
   2. Eyewash equipment.
   3. Combination units.
   4. Water-tempering equipment.

1.3 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.


D. Tepid: Moderately warm.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For emergency plumbing fixtures to include in operation and maintenance manuals.
1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Flushing-Fluid Solution: Separate lot and equal to at least 200 percent of amount of solution installed for each self-contained unit.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
B. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."
C. NSF Standard: Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

PART 2 - PRODUCTS

2.1 EYEWASH EQUIPMENT

A. Sink, Swivel-Type, Plumbed Eyewash Unit:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Guardian Equipment Co.
      c. Haws Corporation.
   2. Capacity: Not less than 0.4 gpm for at least 15 minutes.
   3. Supply Piping: Chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
   4. Control-Valve Actuator: Movement of spray-head assembly to position over sink.
   5. Spray-Head Assembly: Two spray heads with offset piping.
   6. Mounting: Deck next to sink.

2.2 COMBINATION UNITS

A. Standard, Plumbed Emergency Shower with Eyewash Combination Units:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Guardian Equipment Co.
      c. Haws Corporation.
   2. Piping:
      a. Supply Material: Galvanized steel or Chrome-plated brass or stainless steel.
      b. Unit Drain: Outlet at back or side near bottom.
   3. Shower:
      a. Capacity: Not less than 20 gpm for at least 15 minutes.
c. Control-Valve Actuator: Pull rod.
d. Shower Head: 8-inch-minimum diameter, chrome-plated brass or stainless steel.
e. Mounting: Pedestal.

4. Eyewash Unit:
   a. Capacity: Not less than 0.4 gpm for at least 15 minutes.
   d. Spray-Head Assembly: Two receptor-mounted spray heads.
   e. Receptor: Chrome-plated brass or stainless-steel bowl.
   f. Mounting: Attached shower pedestal.

B. Accessible, Plumbed Emergency Shower with Eyewash Combination Units:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Guardian Equipment Co.
      c. Haws Corporation.
   2. Piping:
      a. Supply Material: Galvanized steel or Chrome-plated brass or stainless steel.
      b. Unit Drain: Outlet at back or side near bottom.
   3. Shower:
      a. Capacity: Not less than 20 gpm for at least 15 minutes.
      c. Control-Valve Actuator: Pull rod.
      d. Shower Head: 8-inch-minimum diameter, chrome-plated brass or stainless steel.
      e. Mounting: Pedestal.
   4. Eyewash Unit:
      a. Capacity: Not less than 0.4 gpm for at least 15 minutes.
      d. Spray-Head Assembly: Two receptor-mounted spray heads.
      e. Receptor: Chrome-plated brass or stainless-steel bowl.
      f. Mounting: Attached shower pedestal.

C. Standard, Plumbed Emergency Shower with Eye/Face Wash Combination Units:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Guardian Equipment Co.
      c. Haws Corporation.
   2. Piping:
      a. Supply Material: Galvanized steel or Chrome-plated brass or stainless steel.
      b. Unit Drain: Outlet at back or side near bottom.
   3. Shower:
      a. Capacity: Not less than 20 gpm for at least 15 minutes.
      c. Control-Valve Actuator: Pull rod.
      d. Shower Head: 8-inch-minimum diameter, chrome-plated brass or stainless steel.
      e. Mounting: Pedestal.
   4. Eye/Face Wash Unit:
      a. Capacity: Not less than 3 gpm for at least 15 minutes.
      d. Spray-Head Assembly: Two or four receptor-mounted spray heads.
      e. Receptor: Chrome-plated brass or stainless-steel bowl.
f. Mounting: Attached shower pedestal.

D. Accessible, Plumbed Emergency Shower with Eye/Face Wash Combination Units:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Guardian Equipment Co.
      c. Haws Corporation.
   2. Piping:
      a. Supply Material: Galvanized steel or Chrome-plated brass or stainless steel.
      b. Unit Drain: Outlet at back or side near bottom.
   3. Shower:
      a. Capacity: Not less than 20 gpm for at least 15 minutes.
      c. Control-Valve Actuator: Pull rod.
      d. Shower Head: 8-inch-minimum diameter, chrome-plated brass or stainless steel.
      e. Mounting: Pedestal.
   4. Eye/Face Wash Unit:
      a. Capacity: Not less than 3 gpm for at least 15 minutes.
      d. Spray-Head Assembly: Two or four receptor-mounted spray heads.
      e. Receptor: Chrome-plated brass or stainless-steel bowl.
      f. Mounting: Attached to shower pedestal.

2.3 WATER-TEMPERING EQUIPMENT

A. Hot- and Cold-Water, Water-Tempering Equipment:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Guardian Equipment Co.
      c. Leonard Valve Company.
   2. Description: Factory-fabricated equipment with thermostatic mixing valve.
      a. Thermostatic Mixing Valve: Designed to provide 85 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
      b. Supply Connections: For hot and cold water.

2.4 SOURCE QUALITY CONTROL

A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to authorities having jurisdiction.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

1. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.

E. Install shutoff valve and strainer in steam piping and shutoff valve in condensate return piping. Comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Piping Specialties."

F. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."

G. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

H. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

I. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

J. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

K. Fill self-contained fixtures with flushing fluid.
3.3 CONNECTIONS

A. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."

B. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."

C. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.

E. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:
   1. Perform each visual and mechanical inspection.
   2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.
SECTION 22 62 13 - VACUUM PIPING FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Laboratory high-vacuum piping, designated "laboratory high vacuum."

B. Related Requirements:
   1. Section 115313 "Fume Hoods and Other Air Containment Units" for vacuum inlets in laboratory fume hoods.
   2. Section 115310 "Laboratory Casework" for vacuum inlets in laboratory casework.
   3. Section 226219 "Vacuum Equipment for Laboratory Facilities" for vacuum producers and accessories.

1.3 DEFINITIONS

A. Nonmedical laboratory vacuum piping systems include laboratory low-vacuum and laboratory high-vacuum piping systems.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Material Certificates: Signed by Installer certifying that medical vacuum piping materials comply with requirements in NFPA 99.

C. Brazing certificates.

D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For vacuum piping specialties to include in emergency, operation, and maintenance manuals.
1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Quick-Coupler Service Connections: Furnish complete noninterchangeable medical vacuum suction inlets.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Pressure-Seal Joining Procedure for Copper Tubing: An authorized representative who is trained and approved by manufacturer.
   2. Extruded-Tee Outlet Procedure: An authorized representative who is trained and approved by manufacturer.
   3. Shape-Memory-Metal Coupling Joints: An authorized representative who is trained and approved by manufacturer.

B. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications"; or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Laboratory high vacuum operating at 22 in. Hg (560 mm Hg)

2.2 PIPES, TUBES, AND FITTINGS

A. Copper Medical Gas Tube: ASTM B 819, Type L, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service.

B. Copper Water Tube: ASTM B 88, Type M (ASTM B 88M, Type C), seamless, drawn temper.

C. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type that has been manufacturer cleaned, purged, and sealed for medical gas service.

D. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

E. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.
   1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness, full-face type.
   2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

F. Shape-Memory-Metal Couplings:
   1. Manufactures: Subject to compliance with requirements, provide products by one of the following:
      a. Aerofit Inc.
b. Cameron; a Schlumber Co.
c. Motion Industries
d. Smart Tap; Smart Technology.

2. Description: Cryogenic compression fitting made of nickel-titanium, shape-memory alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.

G. Pressure-Seal Fittings:
1. Manufactures: Subject to compliance with requirements, provide products by one of the following:
   a. Nibco Inc
   b. Viega LLC.
2. NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
3. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.

1. Manufactures: Subject to compliance with requirements, provide products by one of the following:
   a. T-DRILL Industries Inc.<Double click here to find, evaluate, and insert list of manufacturers and products.>

I. Flexible Pipe Connectors:
1. Manufactures: Subject to compliance with requirements, provide products by one of the following:
   a. Flex-Hose Co., Inc
   b. Flexicraft Industries
   c. Hyspan Precision Products
   d. Metraflex Company.
2. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   a. Working-Pressure Rating: 250 psig (1725 kPa) minimum.
   b. End Connections: Plain-end copper tube.

2.3 JOINING MATERIALS
A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.
C. Threaded-Joint Tape: PTFE.
2.4 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.

B. Copper-Alloy Ball Valves:
   1. Manufactures: Subject to compliance with requirements, provide products by one of the following:
      a. Nibco Inc.
      b. Tri-Tech Medical
      c. Allied Healthcare products
      d. BeaconMedaes
   3. Description: Three-piece body, brass or bronze.
   4. Pressure Rating: 300 psig (2070 kPa) minimum.
   5. Ball: Full-port, chrome-plated brass.
   6. Seats: PTFE or TFE.
   7. Handle: Lever
   8. Stem: Blowout proof with PTFE or TFE seal.
   9. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions with pressure gauge on one copper-tube extension.

C. Check Valves:
   1. Manufactures: Subject to compliance with requirements, provide products by one of the following:
      a. Nibco Inc.
      b. Tri-Tech Medical
      c. Allied Healthcare products
      d. BeaconMedaes
   2. Description: In-line pattern, bronze.
   3. Pressure Rating: 300 psig (2070 kPa) minimum.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be re-cleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
   1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1.
2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb (0.453 kg) of chemical to 3 gal. (11.3 L) of water.
   a. Scrub to ensure complete cleaning.
   b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of vacuum piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, vacuum producer sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Comply with NFPA 99 for installation of vacuum piping.

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

F. Install piping adjacent to equipment and specialties to allow service and maintenance.

G. Install vacuum piping with 1 percent slope downward in direction of flow.

H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than piping pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.

I. Install eccentric reducers, if available, where vacuum piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

J. Provide drain leg and drain trap at end of each main and branch and at low points.

K. Install thermometer and vacuum gage on inlet piping to each vacuum producer and on each receiver. Comply with requirements in Section 220519 "Meters and Gages for Plumbing Piping."

L. Install piping to permit valve servicing.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and for branch connections. Extruded-tee branch outlets in copper tubing may be made where specified.

O. Install medical vacuum piping from medical vacuum service connections specified in this Section, to equipment specified in Section 226219 "Vacuum Equipment for Laboratory and Healthcare Facilities," and to equipment specified in other Sections requiring medical vacuum service.
P. Piping Restraint Installation: Install seismic restraints on vacuum piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

Q. Install medical vacuum service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

R. Install medical vacuum bottle bracket adjacent to each wall-mounted medical vacuum service connection suction inlet.

S. Connect vacuum piping to vacuum producers and to equipment requiring vacuum service.

T. Install unions in copper vacuum tubing adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.

U. Install unions in PVC vacuum piping NPS 2 (DN 50) and smaller adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.

V. Install flanges in PVC vacuum piping NPS 2-1/2 (DN 65) and larger adjacent to flanged valves and at final connection to each machine, specialty, and piece of equipment.

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 VALVE INSTALLATION

A. Install shutoff valve at each connection to and from vacuum equipment and specialties.

B. Install check valves to maintain correct direction of vacuum flow to vacuum-producing equipment.

C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install flexible pipe connectors in suction inlet piping to each vacuum producer.

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
D. Threaded Joints: Apply appropriate tape to external pipe threads.

E. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" chapter. Do not use flux. Continuously purge joint with oil-free dry nitrogen during brazing.

F. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.

G. Extruded-Tee Outlets: Form branches in copper tube according to ASTM F 2014, with tools recommended by tube manufacturer.

H. Flanged Joints:
   1. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.
   2. PVC Piping: Install PVC flange on PVC pipes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

I. Pressure-Sealed Joints: Join copper tube and copper and copper-alloy fittings with tools recommended by fitting manufacturer.

J. Shape-Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of shape-memory-metal coupling joints.

K. Solvent-Cemented Joints: Clean and dry joining surfaces. Join PVC pipe and fittings according to the following:
   1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   2. Apply primer and join according to ASME B31.9 and ASTM D 2672 for solvent-cemented joints.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

C. Vertical Piping: MSS Type 8 or Type 42, clamps.

D. Individual, Straight, Horizontal Piping Runs:
   1. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
   2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

F. Base of Vertical Piping: MSS Type 52, spring hangers.

G. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
H. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch- (10-mm-) minimum rods.

I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   2. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
   3. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   4. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
   5. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
   6. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
   7. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
   8. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
   9. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
  10. NPS 3-1/2 (DN 90): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
   11. NPS 4 (DN 100): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
   12. NPS 5 (DN 125): 18 feet (5.5 m) with 1/2-inch (13-mm) rod.
   13. NPS 6 (DN 150): 20 feet (6 m) with 5/8-inch (16-mm) rod.
   14. NPS 8 (DN 200): 23 feet (7 m) with 3/4-inch (19-mm) rod.

J. Install supports for vertical copper tubing every 10 feet (3 m).

K. Install identifying labels and devices for laboratory vacuum piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

3.6 FIELD QUALITY CONTROL FOR LABORATORY FACILITY NONMEDICAL VACUUM PIPING

A. Testing Agency: Engage qualified testing agency to perform field tests and inspections of vacuum piping in nonmedical laboratory facilities and to prepare test and inspection reports.

B. Tests and Inspections:
   1. Piping Leak Tests for Vacuum Piping: Test new and modified parts of existing piping. Cap and fill vacuum piping with oil-free, dry nitrogen. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
      a. Test Pressure for Copper Tubing 150 psig (1035 kPa)
   2. Repair leaks and retest until no leaks exist.
   3. Inspect filters for proper operation.

C. Remove and replace components that do not pass tests and inspections and retest as specified above.

3.7 PROTECTION

A. Protect tubing from damage.

B. Retain sealing plugs in tubing, fittings, and specialties until installation.

C. Clean tubing not properly sealed, and where sealing is damaged, according to "Preparation" Article.
3.8 PIPING SCHEDULE

A. Connect new copper tubing to existing copper tubing with memory-metal couplings.

B. Connect PVC pipe to copper tube with transition fittings.

C. Flanges may be used where connection to flanged equipment is required.

D. Laboratory High-Vacuum Piping: Use one of the following piping materials for each size range:
   1. NPS 4 (DN 100) and Smaller: Copper medical gas tube, press-type fittings, and pressure-sealed joints.
   2. All Sizes: Extruded-tee fittings and brazed joints may be used instead of standard tee fittings.

3.9 VALVE SCHEDULE

A. Shutoff Valves:
   1. Copper Tubing: Copper-alloy ball valve with manufacturer-installed ASTM B 819, copper-tube extensions.

B. Zone Valves: Copper-alloy ball valve with manufacturer-installed ASTM B 819, copper-tube extensions with pressure gage on one copper-tube extension.

END OF SECTION
SECTION 22 62 19 - VACUUM EQUIPMENT FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Liquid-ring vacuum pumps.
   2. Rotary, dry-claw vacuum pumps.
   3. Rotary, sliding-vane vacuum pumps.

B. Related Requirements: Retain subparagraph below to cross-reference requirements Contractor might expect to find in this Section but are specified in other Sections.

1.3 DEFINITIONS

A. Actual Air: Air delivered at vacuum producer inlet. Flow rate is air measured in acfm.

B. Laboratory Vacuum Equipment: Vacuum producers and accessories for nonmedical laboratory facilities.

C. Standard Air: Free air at 68 deg F and 1 atmosphere before compression or expansion and measured in scfm.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For vacuum producers.

   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
   4. Include diagrams for power, signal, and control wiring.
1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Seismic Qualification Certificates: For vacuum producers, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For vacuum equipment to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Laboratory Vacuum Equipment for Nonmedical Laboratory Facilities: An employer of workers trained and approved by manufacturer.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum equipment testing indicated, that is an NRTL, and that is acceptable to authorities having jurisdiction.
   1. Qualify testing personnel according to ASSE 6020 for inspectors and ASSE 6030 for verifiers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Vacuum producers and accessories shall withstand the effects of earthquake motions determined according to ASCE/SEI 7
1. The term "withstand" means "the vacuum producer and receiver will remain in place without separation of any parts when subjected to the seismic forces specified."

2. Component Importance Factor: 1.0.

2.2 GENERAL REQUIREMENTS FOR VACUUM PUMPS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 99, "Health Care Facilities," for vacuum equipment and accessories for medical vacuum systems.

C. Comply with UL 544, "Medical and Dental Equipment," for medical vacuum equipment.

D. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty vacuum pumps and receivers.

E. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
   1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
   3. Control Voltage: 120-V ac or less, using integral control power transformer.
   5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
   6. Automatic control switches to alternate lead-lag vacuum pumps for duplex vacuum pumps.
   7. Instrumentation: Include vacuum pump inlet and receiver vacuum gages, hour meter, vacuum pump discharge-air and coolant temperature gages, and control transformer.
   8. Alarm Signal Devices: For connection to alarm system to indicate when backup vacuum pump is operating. The fault alarm will be hard wired or routed over a COMM protocol (BACnet, ModBus, etc.).

F. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; bearing appropriate code symbols.
   1. Interior Finish: Corrosion-resistant coating.
   2. Accessories: Include vacuum relief valve, vacuum gage, and drain.

G. Mounting Frames: Fabricate base and attachment to vacuum pump and components with reinforcement strong enough to resist movement during a seismic event when base is anchored to building structure.
2.3 ROTARY, SLIDING-VANE VACUUM PUMPS

A. Oil-Sealed, Rotary, Sliding-Vane Vacuum Pumps VAC-1

1. Manufacturer: Powerex
2. Description: Packaged unit.
   a. Cleanable inlet screens.
   b. Outlet silencers and oil-mist separators on discharge connections.

B. Capacities and Characteristics:

2. Vacuum Pump(s): Two.
4. Actual-Air Capacity of Each Vacuum Pump: 42 acfm expanded air delivered.
5. Vacuum Required: 24 in. Hg.
7. Motor (Each Vacuum Pump):
   a. Horsepower: 10 HP
   b. Speed: 1750 rpm.
8. Electrical Characteristics:
   a. Volts: 460V
   b. Phase(s): Three.
   c. Hertz: 60
   d. Full-Load Amperes: 27.6

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean vacuum equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for laboratory vacuum applications, according to CGA G4.1, "Cleaning Equipment for Oxygen Service."

3.2 VACUUM EQUIPMENT INSTALLATION

A. Install vacuum equipment for healthcare facilities according to ASSE 6010 and NFPA 99.
B. Equipment Mounting:
   1. Install vacuum producers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
   2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
   3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

C. Install vacuum equipment anchored to substrate.

D. Orient equipment so controls and devices are accessible for servicing.

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Install the following devices on vacuum equipment:
   1. Thermometer, Vacuum Gage, and Pressure Relief Valve: Install on each vacuum pump receiver.
   2. Drain Valves: Install on receivers. Discharge receiver condensate over nearest floor sink. Discharge separator oral evacuation fluids by direct connection into sanitary waste piping system.

3.3 CONNECTIONS

A. Comply with requirements for water-supply piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for drain piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Comply with requirements for vacuum piping specified in Section 226213 "Vacuum Piping for Laboratory and Healthcare Facilities." Drawings indicate general arrangement of piping, fittings, and specialties.

D. Where installing piping adjacent to equipment, allow space for service and maintenance.

E. Connect vacuum piping to vacuum equipment, accessories, and specialties with shutoff valve and union or flanged connection.

F. Connect water supply to vacuum equipment that requires water. Include backflow preventer. Backflow preventers are specified in Section 221119 "Domestic Water Piping Specialties."

3.4 IDENTIFICATION

A. Identify nonmedical laboratory vacuum equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."
B. Identify medical vacuum equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment." and with NFPA 99.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check for lubricating oil in lubricated-type equipment.
3. Check belt drives for proper tension.
4. Verify that vacuum producer outlet piping is clear.
5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
6. Check safety valves for correct settings.
7. Check for proper seismic restraints.
8. Drain receiver tank.
9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
10. Test and adjust controls and safeties.
11. Minimum 2 hours on-site startup service by factory-authorized service representative.

B. Verify that vacuum equipment is installed and connected according to the Contract Documents.

C. Verify that electrical wiring installation complies with manufacturer's submittal and written installation requirements in electrical Sections.

D. Prepare written report documenting testing procedures and results.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain vacuum producers. Minimum 2 hours on-site demonstration required.

B. Refer to Division 1 "Demonstration and Training" and "General Commissioning Requirements" for additional requirements.

END OF SECTION
SECTION 22 66 00 - LABORATORY-WASTE SYSTEMS FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 01 81 13 “Sustainable Design Requirements” for additional Leadership in Energy and Environmental Design (LEED®) certification-related references, definitions, documentation requirements, action plans, meetings, and performance requirements of products and systems.

1.2 SUMMARY

A. Section Includes:
   2. Piping specialties.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant's review.
   2. A completed GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF), as specified in Section 01 81 13 Information to be supplied for this form shall include:
      a. List of all adhesives and sealants installed on the project, within the LEED boundary that were included in the contract.
      b. Cost breakdowns for the materials included in the Contractor or sub-contractor's work. Cost breakdowns shall include total cost plus itemized material costs.
      c. A total estimated weight (lbs.) value of the material applied within the LEED project boundary.
      d. IEQ credit 4, Low Emitting Materials: The VOC content in g/L or applicable certification label for each adhesives, sealants, coatings, paints, etc. per respective LEED requirement.
   3. GBMCF Back-Up Documentation: These documents are used to validate the information provided on the GBMCF (except cost data). For each material listed on the GBMCF, provide documentation to certify the material's attributes, as applicable:
      a. IEQ credit 4, Low Emitting Materials: VOC content or applicable certification label proof in the form of a cutsheet, MSDS, or letter from the manufacturer.
      b. Product cut sheets for materials appearing in the GBMCF. Cut sheets shall be submitted with the Contractor or sub-contractor's stamp, as confirmation that the submitted products are the products installed on the Project.
   4. Contractor is required to collect all LEED submittal documentation from the project's subcontractors and assemble into one (1) package per Section or trade, on the GBMCF provided, for review by the Sustainability Consultant. Submit GBMCF and Back-Up Documentation within 30 days of awarded contract. Incomplete or inaccurate LEED submittals may be used as the basis for rejecting the submitted products or assemblies.

C. Delegated-Design Submittal: For seismic restraints of aboveground piping.
1. Include design calculations for selecting seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Pipe sizes, locations, and elevations.
   2. Other piping in same trench and clearances from sewerage system piping.
   3. Interface and spatial relationship between piping and proximate structures.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For chemical-waste specialties and to include in emergency, operation, and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store piping and specialties with sealing plugs in ends or with end protection.

B. Do not store plastic pipe or fittings in direct sunlight.

C. Protect pipe, fittings, and seals from dirt and damage.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 70.

2.2 PERFORMANCE REQUIREMENTS

A. Single-Wall Piping Pressure Rating: 5-psig air test pressure.

2.3 SINGLE-WALL PIPE AND FITTINGS

A. PE Drainage Pipe and Fittings: Comply with ASTM D 4976.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Performance Pipe.
      c. PolyPipe Brand; Dura-Line.

B. PP Drainage Pipe and Fittings: ASTM F 1412 pipe extruded and drainage-pattern fittings molded, with Schedule 40 dimensions and with fire-retardant additive complying with ASTM D 4101; with fusion-joint ends.
   1. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Georg Fischer Inc.
      b. IPEX USA LLC.
      c. Orion Fittings; a Watts Water Technologies company.

C. Adapters and Transition Fittings: Assemblies with combinations of clamps, couplings, adapters, and gaskets; compatible with piping and system liquid; made for joining different piping materials.

2.4 JOINING MATERIALS

A. Couplings: Assemblies with combinations of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.

B. Adapters and Transition Fittings: Assemblies with combinations of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.

C. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.

2.5 PIPING SPECIALTIES

A. Plastic Dilution Traps:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Georg Fischer Inc.
      b. IPEX USA LLC.
      c. Orion Fittings; a Watts Water Technologies company.
   3. End Connections: Mechanical joint.
   4. Dilution Tanks: 1-gal. capacity, with clear base unless colored base is indicated; with two NPS 1-1/2 top inlets and one NPS 1-1/2 side outlet.
   5. Small Dilution Jars: 1-pint capacity, with clear base unless colored base is indicated; with NPS 1-1/2 top inlet and NPS 1-1/2 side outlet.
   6. Large Dilution Jars: 1-quart capacity; with NPS 1-1/2 top inlet and NPS 1-1/2 side outlet.

B. PP Floor Drains:
   1. Body: With 7- to 9-inch top diameter, with flashing flange and weep holes; and with flashing clamp basket strainer and trap-primer connection.
2. Outlet: Bottom, to match connecting pipe, with NPS 2, NPS 3, NPS 4, or NPS 6 outlet as indicated.

C. Plastic Backwater Valves:
   1. Description: Full-port NPS 3 check valve, PP or PVDF, matching or compatible with system piping and compatible with system liquid, with EPDM seals and flanged ends.

D. High-Silicon-Iron Sink Outlets:
   1. Description: NPS 1-1/2, with clamping device and 4-, 6-, or 8-inch-high overflow fitting, as indicated.
   2. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Flowserve Corporation

PART 3 - EXECUTION

3.1 EARTHWORK

   A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

   A. Chemical-Waste Piping Inside the Building:
      1. Install piping next to equipment, accessories, and specialties to allow service and maintenance.
      2. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
      3. Flanges may be used on aboveground piping unless otherwise indicated.
      4. Install underground fiberglass piping according to ASTM D 3839.
      5. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
      6. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
      7. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
      8. Install piping at indicated slopes.
      9. Install piping free of sags and bends.
     10. Install fittings for changes in direction and branch connections.
     11. Verify final equipment locations for roughing-in.
     12. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
     13. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
3.3 PIPING SPECIALTY INSTALLATION

A. Embed floor drains in 4-inch minimum depth of concrete around bottom and sides. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for concrete.

B. Fasten grates to drains if indicated.

C. Set floor drains with tops flush with pavement surface.

D. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use fittings of same material as sewer pipe at branches for cleanouts and riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.
   1. Set cleanout bodies in earth in cast-in-place concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding grade. Set cleanout plugs in concrete pavement, with tops flush with pavement surface. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for formwork, reinforcement, and concrete requirements.

E. Install backwater valves in horizontal position. Include riser to cleanout at grade.

3.4 JOINT CONSTRUCTION

A. Chemical-Waste Piping Inside the Building:
   2. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.

3.5 HANGER AND SUPPORT INSTALLATION

A. Pipe sizes in this article refer to aboveground single-wall pipiing.

B. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

C. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices. Install the following:
   1. Vertical Piping: MSS Type 8 or MSS Type 42 riser clamps.
   2. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52 spring hangers.

D. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for installation of supports.

E. Support horizontal piping and tubing within 12 inches of each fitting and coupling.
F. Support vertical piping and tubing at base and at each floor.

G. Rod diameter may be reduced one size for double-rod hangers, to minimum of 3/8 inch.

H. Install vinyl-coated hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 2: 33 inches with 3/8-inch rod.
   2. NPS 2-1/2 and NPS 3: 42 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
   4. NPS 6: 48 inches with 3/4-inch rod.
   5. NPS 8: 48 inches with 7/8-inch rod.

I. Install supports for vertical PP piping every 72 inches.

J. Install hangers for high-silicon-iron piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
   4. NPS 6: 60 inches with 3/4-inch rod.
   5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.
   6. NPS 15: 60 inches with 1-inch rod.
   7. Spacing for horizontal pipe in 84-inch lengths may be increased to 84 inches. Spacing for fittings is limited to 60 inches.

K. Install supports for vertical high-silicon-iron piping every 15 feet.

L. Support piping and tubing not listed above according to MSS SP-58.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Make connections to existing piping, so finished Work complies as nearly as practical with requirements specified for new Work.

C. Use commercially manufactured wye fittings for sewerage piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.

D. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.

E. Install piping adjacent to equipment to allow service and maintenance.

3.7 LABELING AND IDENTIFICATION

A. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for labeling of equipment and piping.
   1. Use warning tape or detectable warning tape over ferrous piping.
   2. Use detectable warning tape over nonferrous piping and over edges of underground structures.
3.8 FIELD QUALITY CONTROL

A. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place and again at completion of Project.
   1. Defects requiring correction include the following:
      a. Alignment: Less than full diameter of inside of pipe is visible between inspection points.
      b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      c. Crushed, broken, cracked, or otherwise damaged piping.
      d. Hydrostatic Tests for Drainage Piping:
         1) Allowable leakage is a maximum of 50 gal./inch of nominal pipe size per mile of pipe during 24-hour period.
         2) Close openings in system and fill with water.
         3) Purge air and refill with water.
         4) Disconnect water supply.
         5) Test and inspect joints for leaks.
      e. Air Tests for Drainage Piping: Comply with UNI-B-6.

B. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Chemical-waste piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 CLEANING

A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Clean piping by flushing with potable water.

3.10 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below unless otherwise indicated.

B. Single-Wall, Chemical-Waste Sewerage Piping: Use any of the following piping materials for each size range:
   1. NPS 2 to NPS 4: High-silicon-iron, hub-and-plain-end pipe and fittings and caulked High-silicon-iron, mechanical-joint pipe and fittings and coupled joints.
   2. NPS 1-1/2 to NPS 4: PP drainage pipe and fittings and fusion joints.
   4. NPS 6: PP drainage pipe and fittings and fusion joints.
5. NPS 8 to NPS 12: High-silicon-iron, hub-and-plain-end pipe and fittings and calked joints.
6. NPS 8 to NPS 12: PP drainage pipe and fittings and fusion joints.

C. Underground, Double-Containment, Chemical-Waste Sewerage Piping: Use any of the following piping materials for each size range:
   1. NPS 2 to NPS 12: PP double-containment drainage pipe and fittings.

D. Aboveground Chemical-Waste Piping: Use any of the following piping materials for each size range:
   1. NPS 1-1/2 to NPS 6: PP drainage piping and fusion joints.
   2. NPS 1-1/2 to NPS 6: Use NPS 2 to NPS 6 high-silicon-iron piping with hub-and-plain ends and calked joints.
   3. NPS 1-1/2 to NPS 4: High-silicon-iron piping with mechanical-joint ends, mechanical couplings, and coupled joints.
   4. NPS 8 to NPS 12: High-silicon-iron piping with hub-and-plain ends and calked joints.

E. Under Slab-on-Grade, Indoor, Chemical-Waste Piping: Use any of the following piping materials for each size range:
   1. NPS 1-1/2 to NPS 6: PP drainage piping and fusion joints.
   2. NPS 1-1/2 to NPS 6: NPS 2 to NPS 4 high-silicon-iron piping with hub-and-plain ends and calked joints.
   3. NPS 8: High-silicon-iron piping with hub-and-plain ends and calked joints.

END OF SECTION
SECTION 22 67 00 - PROCESSED WATER SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes deionized-water and reverse-osmosis-water piping.

1.3 PERFORMANCE REQUIREMENTS
   A. Minimum Working Pressure Ratings:
      1. Deionized-Water Piping: 150 psig unless otherwise indicated.
   B. Seismic Performance: Water piping shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Sustainable Design Submittals:
      1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
      2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.5 INFORMATIONAL SUBMITTALS
   A. Seismic Qualification Certificates: For water piping, accessories, and components, from manufacturer.
      1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.
   B. Welding certificates.
C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."


PART 2 - PRODUCTS

2.1 PLASTIC PIPE AND FITTINGS

   1. Schedule 40, Pipe and Fittings: Pipe made to ASTM D 2447, Schedule 40 or SDR 11 dimensions; with socket- or butt-fusion fittings matching pipe dimensions.

   1. Schedule 80, Pipe and Fittings: Pipe made to ASTM D 2447, Schedule 80 dimensions; with socket fittings matching pipe dimensions.
   2. Electro-Fusion Fitting: Electrical-resistance heating coil for PP piping joints.

2.2 STAINLESS-STEEL TUBING

A. Stainless-Steel Tube: ASTM A 270, Grade TP304L or TP316L, seamless, sanitary tube of pharmaceutical quality, with wall thickness not less than ASTM A 312/A 312M, Schedule 5 unless otherwise indicated; with seamless, stainless-steel fittings matching tube thickness and grade, for welded joints.

B. Stainless-Steel Tube Fittings: Fabricated of same material and thickness as tubing for butt welding.

C. Finish on Inside Surface of Tubes and Fittings: Ra 20 micro-inch maximum roughness.

2.3 TRANSITION FITTINGS

A. Transition Fittings: Couplings, flanges, or other manufactured fittings; same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.4 PP VALVES

A. PP Ball Valves:
   1. Description:
      b. Pressure Rating: 150 psig at 73 deg F.
      d. Body Design: Union type.
e. End Connections: Detachable, butt or socket.
 g. Port: Full.
 h. Seats: PTFE.
 k. Handle: Tee shaped.

B. PP Butterfly Valves:
  1. Description:
     a. Pressure Rating: 150 psig at 73 deg F.
     c. Body Design: Lug or wafer type.
     d. Seat: FKM rubber.
     e. Disc: ASTM D 4101, PP resin
     f. Stem: Stainless steel.
     g. Stem Seals: FKM-rubber O-rings.
     h. Handle: Lever type with locking device.

C. PP Ball-Check Valves:
  1. Description:
     a. Pressure Rating: 150 psig at 73 deg F.
     d. End Connections: Detachable, socket.
     e. Ball: ASTM D 4101, PP resin.

D. PP Swing-Check Valves:
  1. Description:
     a. Pressure Rating: 150 psig at 73 deg F.
     d. End Connections: Flanged.
     f. Disc and Arm: ASTM D 4101, PP resin.
     g. Gasket and Seals: FKM rubber.

E. PP Diaphragm Valves:
  1. Description:
     a. Pressure Rating: 150 psig at 73 deg F.
     d. End Connections for NPS 2 and Smaller: Detachable, socket.
     e. End Connections for NPS 2-1/2 and NPS 3: Flanged.
     f. Diaphragm: FKM rubber.
     g. Seals: FKM-rubber O-rings.
     h. Handle: Wheel type.
PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of water piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for removal of ceiling panel, and coordinate with other services occupying that space.

F. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

G. Install piping to permit valve servicing.

H. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure ratings unless otherwise indicated.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

L. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."

M. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 18 "Escutcheons for Plumbing Piping."

3.2 JOINT CONSTRUCTION

A. Where specific joint construction is not indicated, follow piping manufacturer's written instructions.

B. PP Piping Electro-Fusion Joints: Make according to ASTM F 1290.

C. PP Piping Heat-Fusion Joints: Make according to ASTM D 2657.
D. Join dissimilar pipe materials with transition fittings compatible with pipe materials being joined.

3.3 VALVE INSTALLATION

A. Install sectional valves close to mains on each branch and riser serving equipment.

B. Install shutoff valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves of same size as the pipe or tube in which they are installed unless otherwise indicated.

E. Install plastic valves of the same material as the plastic pipe in which they are installed.

F. Install stainless-steel valves in stainless-steel tubing.

G. Install valves in horizontal piping with stem at or above center of pipe.

H. Install valves in position to allow full movement of stem and lever handle.

I. Install ball-check valves in horizontal or vertical position so ball will unseat during normal flow.

J. Install swing-check valves in horizontal position with the hinge pin level.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
   3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
   5. Clamps for Vertical Piping: MSS Type 8 or Type 42.
   6. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
   7. Multiple, Straight, Horizontal Piping Runs, 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, to minimum 3/8 inch.
F. Install padded hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1 and Smaller: 32 inches with 3/8-inch rod.
   2. NPS 1-1/4 to NPS 2: 48 inches with 3/8-inch rod.
   3. NPS 2-1/2 and NPS 3: 48 inches with 1/2-inch rod.

G. Install padded supports for vertical PP piping NPS 2-1/2 and larger every 120 inches and midstory for NPS 2 and smaller.

H. Install hangers for stainless-steel tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   3. NPS 2-1/2: 108 inches with 1/2-inch rod.
   4. NPS 3: 10 feet with 1/2-inch rod.

I. Install supports for vertical stainless-steel tubing every 10 feet.

J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

C. Connect deionized-water piping to equipment and service outlets with unions or flanges.

3.6 IDENTIFICATION

A. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

A. Test new piping, and parts of existing piping that have been altered, extended, or repaired, for leaks and defects.
   1. Schedule tests and their inspections by authorities having jurisdiction, with at least 24 hours' advance notice.
   2. Do not cover piping or put into service before inspection and approval.
   3. Test completed piping according to authorities having jurisdiction. If authorities having jurisdiction do not have published procedures, perform tests as follows:
      a. Hydrostatic Tests: Test piping at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 150 psig.
   4. Replace leaking joints with new materials and retest until no leaks exist.
   5. Submit separate reports for each test.
3.8 CLEANING

A. Use procedures prescribed by District or, if not prescribed, use procedures described below:
   1. Before using, purge new piping and parts of existing piping that have been altered, extended, or repaired.
   2. Clean piping by flushing with deionized water.

3.9 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping, and of same or compatible material, may be used in applications below.

B. Deionized-Water Piping: Use any of the following piping materials for each pipe size range:
   1. NPS 3 and Smaller: PP pipe and fittings and heat-fusion joints.
   2. NPS 3 and Smaller: PP pipe and fittings and electro-fusion joints.
   3. NPS 3 and Smaller: Stainless-steel sanitary tubing and welded joints.

3.10 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shut off Duty: Install ball valves in piping NPS 2 and smaller. Install butterfly or diaphragm valves for NPS 3 piping.
   2. Throttling Duty: Install ball valves in piping NPS 2 and smaller. Install diaphragm valves for NPS 3 piping.

END OF SECTION
SECTION 23 00 00 – HVAC GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Division 01.

B. The requirements of the General Conditions and Supplementary Conditions.

1.2 SUMMARY

A. Furnish and install a complete (fully tested, adjusted, and ready for operation) mechanical system and fully automatic indoor space thermal conditioning and ventilation (commonly “HVAC”) system with associated controls as described by the Contract Drawings and Specifications.

B. The HVAC systems and design described in the Project documents reflect a building designed for low consumption of energy and water and minimum environmental footprint. Any modifications to the systems described herein shall maintain or improve on the sustainability and energy efficiency features of the project.

C. All design modifications that pertain to system selection, system energy efficiency and energy use, material selection and indoor air quality issues shall require the approval of Integral Group.

D. Include incidental details not usually shown or specified, but necessary for proper installation and operation.

E. Check, verify, and coordinate Work with Contract Drawings and Specifications prepared by all other trades. Include modifications, relocations, and adjustments necessary to complete work or avoid interference with other trades.

F. Where architectural features govern location of Work, refer to Architectural Drawings.

G. Contractor may install additional piping, fittings, and valves, not shown on the drawings, for testing purposes or convenience of installation. Where such materials are installed, they shall comply with the specifications and shall be properly sized for the system and operation. Remove such installed materials when they interfere with design conditions or as directed by the Architect.

H. LEED: This building shall be LEED certified. Contractor and their subs shall provide all relevant support documentation pertaining to the LEED credits that relate to their work.

I. Commissioning: The scope of work for the Contractor shall not include the duties of the Commissioning Authority (CxA). Contractor will be required, however, to include in their scope of work duties relevant to the commissioning process, including but not limited to training of owner's personnel in the operation of the HVAC equipment, providing manufacturer's startup and pre functional checklists and contractor-provided pre-functional and startup checklists to Commissioning Authority, performing and documenting pre-functional tests for HVAC equipment, performing and documenting functional tests for HVAC equipment, supporting DDC Contractor and Test and Balance Contractor in the performance of their duties, and providing operations and maintenance manuals.
1.3 CODES AND STANDARDS

A. All work and materials shall be in full accordance with the latest local rules and regulations, applicable sections of the California Code of Regulations, Title 24, State Fire Marshal, the Safety Orders of the Division of Industrial Safety, the California Electric Code and applicable State requirements. Nothing in these Plans and Specifications is to be construed to permit work not conforming to these requirements.

B. Wherever the Specifications call for or describe materials or construction of better quality or larger sizes than are required by the above rules and regulations, these Specifications shall govern. Should there be any direct conflict between the above rules and regulations and the Specifications the rules shall govern.

C. Equipment shall have UL label listing.

1.4 DRAWINGS

A. Layout of the equipment and work is diagrammatic, unless specifically dimensioned. Drawings and details shall be checked for interferences before installing the work. Any interference noted between different drawings, and between drawings and actual field conditions shall be brought to the attention of the Architect and Engineer of Record for a decision. The right is reserved to make any reasonable change in location of equipment without additional expense to the Owner.

B. For purposes of clarity and legibility, drawings are diagrammatic to the extent that many offsets, bends, special fittings, exact locations of items are not indicated, unless specifically dimensioned. Exact routing of piping and ductwork and locations of equipment shall be governed by structural conditions and obstructions. Contractor shall make use of all data in Contract Drawings and Specifications and field conditions.

C. In the event a major re-routing of a system appears necessary, Contractor shall prepare and submit for approval, shop drawings of the proposed rearrangement. Because of the diagrammatic nature and small scale of the Contract Drawings, all necessary offsets, adjustments, and transitions required for the complete installation are not shown. Contractor shall carefully investigate the structural and finish conditions affecting all the Work and shall arrange such Work accordingly, furnishing such fittings, equipment, accessories, etc., as may be required to meet such conditions, at no increase in Contract Sum.

D. The construction documents for this project were prepared by the design team using BIM (Building Information Modeling). Using this software by the design team does not relieve the Contractor from performing the necessary coordination to provide complete, code compliant and operational building systems. The plans and sections provided are diagrammatic and show the design intent, these are not intended to be used for fabrication or installation. Contractor is responsible for generating shop drawings for fabrication that meet the design intent as shown on the Contract Documents. The exact location of the piping, ductwork, electrical and support components are to be determined by the Contractor. All building sections and details provided are for information only and do not relieve the Contractor from performing final coordination. Contractor is responsible for coordinating with all other trades.

E. All dimensions and locations of equipment, doors, partitions, etc., are to be taken from the architectural plans but shall be verified at the site.
1.5 MECHANICAL SUBMITTAL PROCEDURES

A. See Division 01 “Administrative Requirements”, for submittal procedures.

B. Mechanical and related submittals are, in addition, subject to the requirements of this Article. In the event of a conflict between the requirements of Division 01 and this Article, the requirements of this Article shall supersede and take precedence over those of Division 01.

C. For DDC Building Automation Systems, see also SUBMITTALS in Part 1 of Section 255000 for additional submittal requirements and a detailed submittal schedule.

D. Engineer of Record will review submittals and provide comments within the following timeframe after receipt by the Engineer:
   1. For typical submittals, allow 10 working days.
   2. For large or complex submittals, allow 15 working days. Determination of “large and complex” submittal shall be at the discretion of the Engineer of Record.
   3. Do not send Engineer of Record more than 10 submittals in a contiguous period of 5 working days. If excess submittals are received, review period will be extended as necessary to perform proper review. Submittals will be reviewed in priority determined by Engineer of Record in consultation with Architect and Contractor.
   4. These submittal review periods supersede and take precedence over periods defined in Division 01, unless Division 01 allows for longer review periods.
   5. Submittal review periods shall not be reduced from the times herein except by agreement with the reviewing entity, in advance and in writing.

E. Submittal documentation and drawings shall consistently use the same abbreviations, symbols, nomenclature and identifiers. Use the same identifiers (e.g. equipment tags) used in Contract Drawings.

F. Submittals shall be provided in digital format.
   1. Provide a separate file for each submittal. For submittal packages, provide a separate file for each subsection (e.g. hardware cutsheets and shop drawings for the same Section shall be provided as separate files).
   2. Product cutsheets, test forms and other text documents shall be provided in word searchable digital format. Acceptable formats are MS Word, PDF (generated from another electronic document and word-searchable; scans of paper documents are not acceptable), and HTML; other formats require approval prior to submission.
   3. Drawings and schematics shall be provided in PDF format and in AutoCAD compatible format.
   4. Scanned paper documents are not acceptable
      a. Exception: original signed documents, such as qualifications, inspection certificates, and warranty documents.
   5. Hardcopy (paper) submittals are not acceptable and shall not be provided except as noted elsewhere.
   6. Submittals provided in the wrong format will be returned without action.

G. Submission and Resubmission Procedure
   1. Optional Pre-Submittals: At Contractor’s option, material may be submitted unofficially via email directly to the Engineer of Record for review and comment prior to formal submission. Comments provided by the Engineer are not official and may be changed or additional comments may be provided on the formal submittal. The intent of pre-
submittals is to reduce paperwork and review time, and to provide a venue to discuss technologies, products, designs or implementation strategies that are novel or unique.

2. Each submittal shall have a unique serial number that includes the associated Specification Section followed by a number for each sub-part of the submittal for that Specification Section, such as SUBMITTAL 230000-01. There is no requirement to assign particular serial numbers to any specific submittals – serial number assignment is arbitrary. The only requirements are that the serial numbers be sequential (to avoid confusing gaps) and, most importantly, consistent across all submittal correspondence.

3. Each resubmittal shall have the original unique serial number plus unique revision number such as SUBMITTAL 230000-01 REVISION 1.

4. Submit one copy of submittal in electronic format. Submissions made in the wrong format will be returned without action.

5. Include with each submittal and resubmittal a copy of the relevant specification section(s) noting on each paragraph and sub-paragraph(s) the following:
   a. CONFORMS: Contractor has verified that the submitted product conforms to the noted requirement(s).
   b. CONFORMS AS NOTED: Contractor has verified that the submitted product conforms to the noted requirement(s) by means of being equal to or higher quality and / or performance.
   c. NON-CONFORM: Contractor has verified that the submitted product does not conform to the noted requirement(s) and delineates each deviation from the specification requirements.
   d. NOT APPLICABLE: Contractor has verified that the noted requirement(s), in their opinion do not apply to this product, delineating the reasons for this decision.
   e. Include with each submittal and resubmittal a copy of the relevant specification section(s) the printed name of the contractor reviewer, their signature, the company name, and date of review.

6. Revise submittal
   a. Respond to all comments:
      1) Revise initial submittal to resolve review comments and corrections.
      2) Provide complete responses to comments or suggestions which are not practical to implement in the opinion of the Contractor.
   b. Indicate any changes that have been made other than those requested.
   c. Clearly identify resubmittal by original submittal number and revision number.
   d. Resubmittals that are not responsive to all comments will be returned without action.

7. Resubmit revised submittals until no exceptions are taken.

8. Once submittals are accepted with “No Exceptions Taken” or “Approved As Noted”, provide:
   a. Complete submittal of all accepted drawings and products in a single electronic file.
   b. Copies for coordination with other trades, if and as required by the General Contractor or Owner’s Representative.

H. Submit shop drawings, a list of proposed material and equipment manufacturers and the names of Subcontractors.

I. Shop drawings shall be provided for all mechanical systems for all floors of the building. Mechanical shop drawings shall also be provided for the underslab systems (under the foundation slab) and slab-embedded systems such as hydronic radiant loops and controls.

J. Materials and methods with which the words “for approval” or “approved” are used, and materials and methods which differ from those specified, shall be submitted.
K. Prepare and submit shop drawings, sections, details and diagrams to minimum scale \( \frac{1}{4}" = 1' - 0" \). Pump rooms and mechanical rooms shall be \( \frac{1}{2}" = 1' - 0" \) minimum scale. Drawings shall be coordinated, dimensioned and indicate equipment, pipe, duct, fire protection, and electrical in relation to architectural and structural features. Include minor piping, drains, air vents, etc. Indicate exact locations and elevations of valves, piping specialties, access doors, dampers, etc. Electronic submittal is encouraged.

L. Submit manufacturer’s specifications, product source, data sheets, certified equipment drawings and installation instructions, including installation dimensions, clearances, weights, materials, finishes, color selection, accessories, acoustical characteristics, capacity and full load and part load performance curves; complete with electrical data, motor horse power, KW; motor efficiency, amperage, voltage phases and wiring diagrams. Identify the particular specification section number, paragraph and equipment identification number per equipment schedule. Note that suppliers (wholesalers and distributors) data sheets are not acceptable unless they are also manufacturers of the product being submitted.

M. Fan and pump systems, with equipment in parallel, shall have performance curves noting single equipment operation and all iterations of additional equipment.

N. Certified Equipment Drawings (8-1/2" x 11" sheets) shall be indexed in accordance with Specification Section. Drawings to be submitted at a later date shall be marked with a page as a placeholder for insertion when submitted. The original submittal shall note which shop drawings will be submitted later. Marked-up catalogs are not acceptable and will be returned without action. Electronic submittal is required.

O. Engineer of Record’s review of submittals is for limited purpose of verifying conformance with information given and design concept expressed in Contract Drawings and Specifications. Engineer’s review is not for purpose of determining accuracy or completeness of items such as dimensions and quantities, which remain responsibility of Contractor.

P. Contractor shall not commence with fabrication or installation of any equipment or system until the associated submittals have been approved by the Engineer of Record and returned with “no exceptions” taken. Contractor shall be solely liable for any costs incurred from starting fabrication before approved submittals are returned.

Q. All final approved submittals and equipment datasheets shall be provided, in PDF format, to the owner as part of the as-built drawing set and shall be text searchable.

1.6 COORDINATION DRAWINGS

A. Utilize the latest version of 3D AutoCAD, Navisworks, and/or Revit software for the Coordination Drawings. No proprietary software of any kind shall be used other than that indicated. Drawing paper size shall not be larger than FULL SIZED Contract Drawings, and in no case larger than 30” x 42”. Coordinate available space with ALL other trades involved.

B. Provide Coordination Drawings in digital electronic format. Provide both native file format (AutoCAD, Navisworks, or Revit) and PDF format files. Hardcopy drawings are not acceptable.

C. These drawings are to show registers, grilles, diffusers, duct sizes, elevation of bottom of duct, pipe sizes, valves and accessories, elevation of bottom of pipe, all elevations of materials and/or systems throughout each floor inclusive of hanger components, seismic bracing if applicable, and any component of construction that impacts vertical and/or horizontal space. In addition, the locations of all valves, dampers, and other items requiring access for service and maintenance are to be shown. The drawings are to also show electrical, structural beams,
architectural bracing, structural bracing, ceiling heights, access doors, walls, floor to floor dimensions, columns, doors and other major architectural and structural features as shown on the architectural and structural drawings. Where the routing of work differs from that indicated on the Contract Drawings, such areas are to be indicated by highlighting with a note describing the reason for the change.

D. Rerouting of any system or part thereof shall be submitted separately in order to obtain concurrence of the Engineer of Record. Submitted rerouting must include fully documented proposed solutions with all trades coordinated. Contractor is fully responsible for coordination of systems included herein. Any effort by Engineer of Record beyond answering Contractor’s questions will be at Contractor’s expense, including attending coordination meetings, review of interim plans, or review of incomplete questions (routing issues without suggested solutions).

E. The Contractor and subcontractors are responsible to review and resolve any real or apparent interferences or conflicts as indicated by the coordination drawings produced by each trade.

F. After all conflicts or interferences are resolved, develop a final composite drawing showing the agreed upon routing, layout and juxtaposition of all duct work, conveyers, piping, major conduit, valves, panels, lighting fixtures and all other major mechanical, plumbing and electrical installations. In the preparation of all the final Coordination Drawings, large scale details as well as cross and longitudinal sections are required to fully delineate all conditions.

G. Submit the Coordination Drawings as digital electronic files to Engineer of Record for review and comment, as indicated under "Shop Drawings" above. Coordination Drawings shall be digitally signed-off by all other trades.

H. Contractor shall not commence with fabrication or installation of any equipment or system until the associated shop drawings have been reviewed and returned by the Engineer of Record. Engineer’s review of shop drawings shall not be taken as approval of their contents. Contractor shall be solely liable for any costs incurred due to deviations from the Contract Drawings.

I. No extra compensation will be paid for relocating any duct, pipe, conduit, or other material that has been installed without proper coordination between all trades involved. If any improperly coordinated work, or installed work that is not in accordance with the approved coordination composites, or is specifically noted by the Architect or Engineer of Record for a valid reason, necessitates additional work by the other trades, the costs of all such additional work is to be borne solely by the Contractor.

J. All changes in the scope of work due to revisions formally issued and approved are to be shown on both the individual subcontractor's Shop Drawings and the Coordination Drawings.

1.7 REQUESTS FOR INTERPRETATION AND CLARIFICATION

A. See Division 01 “Project Management”, for RFI procedures and forms.

B. Mechanical RFIs are, in addition, subject to the requirements of this Article. In the event of a conflict between the requirements of Division 01 and this Article, the requirements of this Article shall supersede and take precedence over those of Division 01.

C. Limit each RFI to a single issue or group of related issues.

D. Each RFI shall include a workable no-cost or lowest cost solution recommendation by Contractor.
E. Allow 3 working days from time of RFI receipt by Engineer of Record for review and response.

F. Do not send Engineer of Record more than 10 RFIs in a contiguous period of 5 working days. If excess RFIs are received, review period will be extended as necessary to provide a professional response. RFIs will be reviewed in priority determined by Engineer of Record in consultation with Architect and Contractor.

1.8 MATERIALS AND SUBSTITUTIONS

A. Comply with Division 01 “Product Requirements”.

B. Requests for product or equipment substitution shall be accompanied by a marked up copy of the Engineer of Record’s original specification. For each specified product feature or requirement, Contractor shall note the equivalent feature or attribute of the proposed substitute product or equipment.

C. Shop drawings of proposed material and equipment that differ from the specified materials and equipment, shall be accompanied by drawings that define changes. These drawings shall show modifications of architectural, plumbing, electrical and mechanical work required by the proposed materials and equipment, such as relocation of flues, drains, revised electrical circuits, relocation of roof or wall penetrations, revised foundations, etc.

1.9 COORDINATION WITH OTHER WORK

A. Contractor performing Work under this Section shall become thoroughly familiar with the Drawings and Specifications. Contractor shall adjust the Work to conform with the conditions shown on these drawings to provide the best possible assembly of the combined Work.

B. Obtain necessary information from the other trades regarding location of their work in order that the Work in this Section may be placed in correct position.

C. The inclusion and proper location of supports, pads, sleepers, openings, anchorages, etc. provided by others is the responsibility of the Contractor under this Section. Cutting and/or boring shall be permitted under this Section only with the written approval of the Architect.

D. It shall be the Contractor’s responsibility to coordinate and have provided by other trades where not covered by the Contractor’s scope of work, all electrical wiring and power to equipment, controls and devices, and any other work from other trades as required to provide fully functioning HVAC systems per the Contract Drawings and Specifications.

E. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.10 MANUFACTURER’S DIRECTIONS

A. Manufacturer’s directions shall be followed in cases where the manufacturers of articles used in this contract furnish directions covering points not shown in the Contract Drawings and Specifications.
1.11 **PROTECTION OF WORK**

A. Equipment and materials shall be stored on dunnage and remain wrapped at all times until installed.

B. Duct and piping shall be remain capped during delivery and storage.

C. During installation, all installed duct and piping shall be capped and protected at the end of each working day.

D. Equipment shall be protected from weather and stored in an enclosed, indoor location.

E. Until final acceptance of the work, protect materials from damage and provide adequate and proper storage facilities. Replace damaged or defective work, material, and equipment before requesting final acceptance.

1.12 **WORKMANSHIP**

A. Equipment and materials shall be installed in a neat and workmanlike manner. Materials and equipment not so installed shall, upon order of the Architect or Engineer of Record, be removed and replaced in a satisfactory manner, without change in Contract Sum or additional cost to the Owner.

1.13 **CLOSING IN UNINSPECTED WORK**

A. Do not allow or cause any work to be covered up or enclosed until it has been inspected, tested, and accepted by the Architect, Engineer of Record, and/or Commissioning Authority.

B. Any work enclosed or covered-up prior to inspection and testing shall be uncovered. After the work has been tested, inspected and accepted, repair such materials as may be necessary to restore disturbed work to its original and proper condition at no extra cost to the Owner.

1.14 **EQUIPMENT ANCHORING**

A. Equipment shall be securely anchored to the building structure to prevent shifting or overturning during earthquakes.

1.15 **PRELIMINARY OPERATION**

A. Under this section, Contractor shall supervise and direct preliminary operation of systems should the Owner demand that any portion of the plant, apparatus, or equipment be operated previous to the final completion and acceptance of the work. Expenses for such preliminary operation will be paid by the Owner. Such preliminary operation or payment shall not be construed as an acceptance of the work.

1.16 **"AS-BUILT" DRAWINGS**

A. Comply with Section Division 01 “Project Closeout”.

Contra Costa Community College District
Contra Costa College
C-4016 New Science Building – DSA Backcheck
B. For DDC Building Automation systems, see also COMPLETION REQUIREMENTS in Part 1 of Section 255000 for additional as-built and closeout submittal requirements.

C. As-built drawings shall be furnished in an electronic format. Provide in drafting software (AutoCAD or Revit) native format and also in PDF format.

1.17 FINAL INSPECTION
A. At the time of final inspection, a service representative shall be available to make final adjustments.

1.18 FINAL OPERATION
A. After acceptance of the installation, instruct the Owner's Representative in operation and maintenance, for a period of three (3), non-consecutive working days at a time requested by the Owner during the first year of warranty.

B. At the beginning of the instruction period, deliver to the Owner three (3) copies of a durable binder as described under “Operating Instructions”.

1.19 OPERATING INSTRUCTIONS
A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these Specifications.

B. Division 23 shall compile and prepare documentation for all equipment and systems covered in Division 23 and deliver this documentation to the General Contractor for inclusion in the O&M manuals prior to the training of Owner personnel.

C. In addition, DDC Contractor shall provide O&M material as required by “Completion Requirements” in Part 1 of Section 255000.

D. Provide a summary of operating sequences (start-up, normal run, and shut-down), and control shop drawings in the main mechanical room.

E. Provide three (3) complete sets of Operating Instructions. These instructions shall include brochures, diagrams, maintenance, and operating instructions and parts lists.

F. Provide a copy of the O&M manuals to the Commissioning Authority for review.

1.20 TRAINING OF OWNER PERSONNEL
A. The General Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.

B. The Commissioning Authority (CxA) shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment.

C. The Mechanical Contractor shall have the following training responsibilities:
   1. Provide the CxA with a training plan two weeks before the planned training.
2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, pumps, air conditioning units, air handling units, fans, boilers, terminal units, controls, water treatment systems, etc.

3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

6. The DDC Contractor shall attend sessions other than the DDC System training, as requested, to discuss the interaction of the DDC System as it relates to the equipment being discussed.

7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

8. Training shall include:
   a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
   c. Discussion of relevant health and safety issues and concerns.
   d. Discussion of warranties and guarantees.
   e. Common troubleshooting problems and solutions.
   f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
   g. Discussion of any peculiarities of equipment installation or operation.
   h. Instruction in the use of equipment controls that are integral to equipment or are provided by the equipment manufacturer, such as VRF System controls. This is in addition to and separate from DDC System training (see below) and does not replace or satisfy the requirement for such training, if specified. Equipment controls training shall include at least the following:
      1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system and any interface with security and communication systems.
      2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
      3) If system supports trending, all trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.
      4) Every screen shall be completely discussed, allowing time for questions.
5) Use of keypad or plug-in laptop computer for mobile control access.
6) Use of remote access to the system via phone lines or networks, if applicable.
7) Graphics generation, if applicable.
8) Point database entry and modifications, if applicable

   j. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate. A video record of the training session is suggested but not required.

9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
10. The Mechanical Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
11. Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

D. DDC Contractor.

   1. See TRAINING in Part 3 of Section 255000 for DDC System training requirements and DDC Contractor obligations.
   2. DDC Contractor shall coordinate with Mechanical Contractor and Commissioning Authority regarding training on equipment-integrated or manufacturer-supplied control systems as described above. Such training is the responsibility of Mechanical Contractor but may be adopted by DDC Contractor by mutual agreement, to facilitate a more integrated training experience.

E. Test and Balance (TAB) Contractor. The TAB Contractor shall have the following training responsibilities:

   1. TAB Contractor shall meet with facility staff after completion of TAB and instruct them on the following:

      a. Go over the final TAB report, explaining the layout and meanings of each data type.
      b. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
      c. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
      d. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
      e. Other salient information that may be useful for facility operations, relative to TAB.

1.21 WARRANTY

A. In accordance with Division 01 Project Closeout requirements, Guarantees, Warranties, Bonds, Service & Maintenance Contracts and as follows.

B. Contractor shall leave entire installation in complete working order and free from defects in material, workmanship, or finish.
C. Warranty all materials, equipment, apparatus, and workmanship to be free of defective materials and faulty workmanship for a minimum period of one (1) year from date of Certificate of Occupancy, or per Division 01, whichever is longer.

D. Warranty also services including instructions, adjusting, testing, noise, balancing, etc.

E. For each piece of equipment or device with a manufacturer's warranty in excess of one year, Contractor shall furnish certificate of manufacturer's warranty and contact information for manufacturer's warranty service. Contractor shall also provide a list or table of all equipment with warranties exceeding one (1) year in duration.

F. Provide new materials, equipment, apparatus, labor and/or service, and support to correct or replace that determined by the Owner to be defective or faulty.

G. The Owner reserves the right to make temporary repairs as necessary to keep equipment in operating condition without voiding the guarantees or relieving responsibility during the guarantee period.

H. For DDC System, see WARRANTY and WARRANTY MAINTENANCE in Part 1 of Section 255000. DDC System warranty commences upon the acceptance of COMPLETION REQUIREMENTS described in Part 1 of that Section, which may occur after the Certificate of Occupancy.

I. After a period of 90 calendar days from date of acceptance of systems by Owner, provide, at no cost to the Owner, one service mechanic for an 8-hour period over as many working days as required to repair, replace any latent deficiency.

1.22 SUBMITTALS

A. Welding certificates.

1.23 ACTION SUBMITTALS

A. Product Data: For each type of product in Part 2.

1.24 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
PART 2 - PRODUCTS

2.1 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.


2.2 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PE or PP: Reusable, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.3 SLEEVE SEAL SYSTEMS

A. Description:
   1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
   2. Designed to form a hydrostatic seal of 20-psig.
   3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
   4. Pressure Plates: Carbon steel.
   5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B 633 of length required to secure pressure plates to sealing elements.
2.4 SLEEVE SEAL FITTINGS

A. Description:
1. Manufactured plastic, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.
2. Plastic or rubber waterstop collar with center opening to match piping OD.

2.5 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening. Polished chrome-plated finish.
1. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass.
2. One-Piece, Cast-Brass Type: With set screw.

2.6 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 4 inches above finished floor level.
3. Using grout, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for fire-stopping and fill materials specified in Division 07.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings as new walls and slabs are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water stop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal space around outside of sleeve-seal fittings.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls Above Grade: Cast-iron sleeves or Galvanized Steel pipe sleeves.
2. Exterior Concrete Walls Below Grade: Cast-iron pipe sleeves with sleeve-seal system or Galvanized Steel pipe sleeves with sleeve-seal system.
   a. Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade: Piping Smaller Than: Cast-iron pipe sleeves with sleeve-seal system or galvanized Steel pipe sleeves with sleeve-seal system.
   a. Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs Above Grade:
   a. Piping Smaller Than NPS 6: Galvanized Steel pipe sleeves or Sleeve-seal fittings.
   b. Piping NPS 6 and Larger: Galvanized Steel pipe sleeves.
3.5 ESCUTCHEON INSTALLATION
   A. Install escutcheons for penetrations of walls, ceilings, and floors.

3.6 CUTTING AND OPENINGS
   A. Comply with Division 01 “Cutting and Patching”.

3.7 EQUIPMENT INSTALLATION
   A. Install equipment to minimize pressure drop and allow adequate access headroom unless specific mounting heights are indicated.

   B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated in drawings (note that in some cases non-parallel installation is indicated in the drawing to reduce pressure drop).

   C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

   D. Install equipment to allow right of way for piping installed at required slope.

3.8 CONCRETE BASES
   A. Concrete Bases: Equipment shall be anchored as detailed on the drawings.

      1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.

      2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.

      3. Install anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

      4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

      5. Install anchor bolts to elevations required for proper attachment to supported equipment.

      6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

      7. Use 3000-psi, 145 PCF, concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.9 ERECTION OF METAL SUPPORTS AND ANCHORAGES
   A. Refer to Division 05 Section for structural steel.

   B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

   C. Field Welding: Comply with AWS D1.1.
3.10 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.11 GROUTING

A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION
SECTION 230413 - COMMON SUBMITTAL REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.

1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.

1. Submittal Numbering: See below.
2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition

1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering
1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.
   
   B. Related Sections include the following:
      1. Section 230514 “Variable-Frequency Drives”.
      2. Section 232123 “Hydronic Pumps”.
      3. Section 233400 “HVAC Fans”.

1.3 COORDINATION
   A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
      1. Motor controllers.
      2. Torque, speed, and horsepower requirements of the load.
      3. Ratings and characteristics of supply circuit and required control sequence.
      4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS
   A. Comply with NEMA MG 1 unless otherwise indicated.
   
   B. Duty: Continuous duty at ambient temperature of 104 deg°F (40 deg C) and at altitude of 3300 feet above sea level.
   
   C. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
   
   D. Motors for submersible pumps shall be hermetically sealed.
   
   E. Motors 3/4 HP or greater shall be polyphase unless otherwise indicated.
F. Minimum Motor Service Factor: 1.15.

G. Motors associated with kitchen exhaust systems shall be located outside the exhaust airstream.

2.2 MOTOR ENCLOSURES

A. Totally Enclosed, Fan Cooled (TEFC) for motors located outdoors, or in unconditioned or unventilated indoors areas, or in air streams unless otherwise indicated.

B. Open Dripproof (ODP) for other cases unless otherwise indicated.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficiency, as defined in NEMA MG 1.

C. Polyphase motors shall be suitable for use with Variable-frequency Motor Controllers.

D. Construction:
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes to 1600 volts, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
   3. Provide motor shaft grounding ring.
   5. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

E. Multispeed Motors: Separate winding for each speed.

F. Wiring Terminations:
   1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
   2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.4 SINGLE-PHASE MOTORS

A. Single-phase motors larger than 1/20 HP shall be Electronically Commutated (ECM) unless not offered by the manufacturer.

B. Electronically Commutated Motors (ECM)
   1. Motor shall be brushless DC type specifically designed for HVAC applications with heavy duty ball bearings and Electronic Commutation. It shall contain internal circuitry that converts single phase power into a DC signal. Speed control is achieved through a 0-10 volt DC control signal input through the pre-wired controls wires.
2. The motor shall be speed controllable down to 20% of full speed and 85% efficient at all speeds.

C. Non-ECM
   1. Motors shall be one of the following, to suit starting torque and requirements of specific motor application (listed in order of preference):
      a. Permanent-split capacitor.
      b. Capacitor start, capacitor run.
      c. Capacitor start, inductor run.
      d. Split phase.
   3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
   4. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION
SECTION 23 05 14 - VARIABLE FREQUENCY DRIVES FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. This Section includes solid-state, PWM, Variable Frequency Drives for speed control of three-phase, squirrel-cage induction motors.
   B. Related Sections include the following:
      1. Section 230513 “Common Motor Requirements for HVAC Equipment”.
      2. Division 26 for monitoring and control of motor circuits.

1.3 DEFINITIONS
   A. ASD: Adjustable Speed Drive.
   B. BAS: Building automation system.
   C. DDC: Direct digital control.
   D. EMI: Electromagnetic interference.
   E. IGBT: Insulated-gate bipolar transistor.
   F. LAN: Local area network.
   G. LED: Light-emitting diode.
   H. OCPD: Overcurrent protective device.
   I. PID: Control action, proportional plus integral plus derivative.
   J. PWM: Pulse-width modulated.
   K. RFI: Radio-frequency interference.
   L. VFC: Variable frequency controller.
   M. VFD: Variable frequency drive.
1.4 ACTION SUBMITTALS

A. See Division 01 and Section 230000 “HVAC General Requirements” for submittal procedures. Also may be submitted as Variable-Frequency Controller (VFC), Adjustable Speed Drive (ASD), or similar.

B. Product Data: For each type and rating of VFD indicated.
   1. Include dimensions and finishes.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   3. Include short circuit interrupting capacities in compliance with Division 26.
   4. Include electrical power monitoring information in compliance with Division 26.

C. Shop Drawings: For each VFD indicated.
   1. Include mounting and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Include certification that VFD selection has been coordinated with equipment being served.
   5. Include ventilation means, points of connection, and air path.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Required working clearances and required area above and around VFDs.
   2. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements.
   3. Show support locations, type of support, and weight on each support.
   4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Seismic Qualification Certificates: For each VFD, accessories, and components, from manufacturer.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

D. Product Certificates: For each VFD from manufacturer.


F. Source quality-control reports.

G. Field quality-control reports.
H. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFDs to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 01 "Operation and Maintenance Data," include the following:
   a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
   b. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
   c. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
   d. Routine maintenance requirements for VFDs and all installed components.
   e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
   f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Source Limitations: Obtain VFDs of a single type through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver VFDs covered and protected, in shipping splits of lengths that can be moved past obstructions in delivery path.
B. Store VFDs indoors on dunnage in clean, dry space with uniform temperature to prevent condensation. Protect VFDs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
   1. Ambient Temperature: 0 to 40 deg C.
   2. Humidity: Less than 90 percent (noncondensing).
   3. Altitude: Not exceeding 1000 feet.

1.11 COORDINATION

A. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, control circuits, required control sequence, and duty cycle of motor and load.

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
   1. ABB Low Voltage Drives.
   2. Cerus Industrial, Inc.
   3. Danfoss Inc.
   4. Eaton.
   5. Emerson Industrial Automation.
   7. Rockwell Automation, Inc.
   8. Schneider Electric USA, Inc.
   10. Yaskawa Electric America, Inc.
2.2 VARIABLE FREQUENCY DRIVES

A. Description: Variable-frequency motor drive / controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. IGBT, PWM; NEMA ICS 2, UL 508A listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design A and B, premium efficiency 3-phase induction motor by adjusting output voltage and frequency.
2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

B. Application: Variable torque.

C. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

D. Output Rating:
   1. Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range.

E. Unit Operating Requirements:
   1. Input AC Voltage Tolerance of 380 to 500 V, plus or minus 15 percent.
   2. Input AC Voltage Unbalance: Not exceeding 3 percent.
   3. Input Frequency Tolerance of 50/60 Hz, plus or minus 3 percent.
   4. Minimum Efficiency: 97 percent at 60 Hz, full load.
   7. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
   8. Starting Torque: 100 percent of rated torque or as indicated.
   9. Speed Regulation: Plus or minus 5 percent.
   10. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.

F. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

G. Isolated control interface to allow controller to follow control signal over a 40:1 speed range.
   1. Electrical Signal: 4 to 20 mA at 24 V.

H. Internal Adjustability Capabilities:
   1. Minimum Speed: 5 to 25 percent of maximum rpm.
   2. Maximum Speed: 80 to 100 percent of maximum rpm.
   3. Acceleration: 0.1 to 999.9 seconds.
   4. Deceleration: 0.1 to 999.9 seconds.
   5. Current Limit: 30 to a minimum of 150 percent of maximum rating.

I. Self-Protection and Reliability Features:
   1. Input transient protection by means of surge suppressors.
   2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
   3. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
   4. Critical frequency rejection, with three selectable, adjustable deadbands.


7. Instantaneous line-to-line and line-to-ground overcurrent trips.


10. Short-circuit protection.

11. Motor overtemperature fault.

J. Multiple-Motor Capability: Drive suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

K. Automatic Reset/Restart: Attempts three restarts after fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to drive, motor, or load.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

M. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

N. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

O. Integral Input Disconnecting Means and OCPD: UL 489, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.

2. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.

3. Normally open alarm contact that operates only when circuit breaker has tripped.

2.3 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.

2. Run.

3. Overvoltage.

4. Line fault.

5. Overcurrent.


1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.

2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
3. Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.

C. Historical Logging Information and Displays:
   1. Real-time clock with current time and date.
   2. Running log of total power versus time.
   3. Total run time.
   4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in drive door and connected to indicate the following parameters:
   1. Output frequency (Hz).
   5. Motor torque (percent).
   6. Fault or alarming status (code).
   7. PID feedback signal (percent).
   8. DC-link voltage (VDC).
   9. Set-point frequency (Hz).
   10. Motor output voltage (V).

E. Control Signal Interface:
   1. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
   2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
      a. 0 to 10-V dc.
      b. 0-20 or 4-20 mA.
      c. Potentiometer using up/down digital inputs.
      d. Fixed frequencies using digital inputs.
      e. RS485.
   3. Output Signal Interface:
      a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
         1) Output frequency (Hz).
         2) Output current (load).
         3) DC-link voltage (VDC).
         4) Motor torque (percent).
         5) Motor speed (rpm).
         6) Set-point frequency (Hz).
         7) Instantaneous power consumption
   4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
      a. Motor running.
      b. Set-point speed reached.
      c. Fault and warning indication (overtemperature or overcurrent).
      d. PID high- or low-speed limits reached.
F. Communications: Provide an RS485 interface allowing VFD to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFD to be programmed via BMS control. Provide capability for VFD to retain these settings within the nonvolatile memory.

2.4 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer’s harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.

2.5 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.
   1. Dry and Clean Indoor Locations: Type 1.
   2. Outdoor Locations: Type 3R.
   4. Other Wet or Damp Indoor Locations: Type 4.
   5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFD as "Plenum Rated."

2.6 OPTIONAL FEATURES

A. Remote Indicating Circuit Terminals: Mode selection, status, and fault.

2.7 ACCESSORIES

A. Devices shall be factory installed in enclosure, unless otherwise indicated.


C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

E. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

F. Supplemental Digital Meters:
   1. Elapsed-time meter.
   2. Kilowatt meter.
G. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

I. Cooling Fan and Exhaust System: For NEMA 250; UL 508 component recognized: Supply fan, with intake and exhaust grills and filters.

J. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

K. Spare control-wiring terminal blocks; wired.

2.8 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFDs according to requirements in NEMA ICS 61800-2.
   1. Test each VFD while connected to its specified motor.
   2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

B. VFDs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

C. Examine VFD before installation. Reject VFDs that are wet, moisture damaged, or mold damaged.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

B. Select horsepower rating of controllers to suit motor controlled.
3.3 INSTALLATION

A. VFDs to be mounted by Mechanical Contractor and connected by the Electrical Contractor unless noted otherwise. Electrical Contractor to confirm need for disconnect switch in addition to VFD and provide if necessary.

B. Wall-Mounting: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall.

C. Free Standing: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to Unistrut or similar support system.

D. Roof-Mounting: Install on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

E. Comply with mounting and anchoring requirements specified in Division 26.

F. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26.

3.4 IDENTIFICATION

A. Identify VFDs, components, and control wiring according to Section 230553 "Identification for HVAC Piping and Equipment."

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices and facility's central-control system. Comply with requirements in Division 26.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.
   1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
   2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.6 CONNECTIONS

A. Conduit installation requirements are specified in Division 26. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 26.
3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Inspect VFD, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
   3. Test continuity of each circuit.
   4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
   5. Test each motor for proper phase rotation.
   7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
   9. VFDs will be considered defective if they do not pass tests and inspections.
   10. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.9 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set the taps on reduced-voltage autotransformer controllers.

C. Set field-adjustable circuit-breaker trip ranges as specified in Division 26.

D. Set field-adjustable pressure switches.
3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFDs.

END OF SECTION
SECTION 23 05 16 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary
      Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section Includes:
      1. Flexible-hose seismic expansion joints.
      2. Alignment guides and anchors.
      3. Pipe loops and swing connections.

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of product. Indicate type, manufacturer’s number, size, material,
      pressure rating, end connections, and location for each expansion joint.

1.4 INFORMATIONAL SUBMITTALS
   A. Welding certificates.

1.5 CLOSEOUT SUBMITTALS
   A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE
   A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M,
      "Structural Welding Code - Steel."
   B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according
      to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
   A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures,
      and temperatures.
   B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.
2.2 SEISMIC EXPANSION JOINTS

A. Flexible-Hose Seismic Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flex Pression Ltd.
   b. Flexicraft Industries.
   c. Mason Industries, Inc.
   d. Metraflex Company (The).

2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.

3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.

4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with threaded-joint end connections.
   a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.

5. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.
   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.

   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.

   a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

8. Accessories:
   a. Seismic breakaway coupling, with disengagement rating of 140 percent of static supported weight.
   b. Tether cable.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advanced Thermal Systems, Inc.
   b. Flex-Hose Co., Inc.
   c. Hyspan Precision Products, Inc.
   d. Mason Industries, Inc.
   e. Metraflex Company (The).
2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:
1. Steel Shapes and Plates: ASTM A36/A36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
   a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

3.2 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install two guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.
F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
   1. Anchor Attachment to Steel Structural Members: Attach by welding.
   2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION
SECTION 23 05 19 – METERS GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Pressure gauges and pressure gauge taps.
   2. Thermometers
   3. Thermometer wells (thermowells).
   4. Test plugs and test plug kits.

B. Related Sections:
   1. Section 232113 "Hydronic Piping".

1.3 REFERENCE STANDARDS

A. ASME B40.100 – Pressure Gauges and Gauge Attachments; The American Society of Mechanical Engineers; 2013.


1.4 ACTION SUBMITTALS

A. See Division 01 and Section 230000 "HVAC General Requirements" for submittal procedures.

B. Product Data: Provide table that indicates use, operating range, total range and location for manufactured components.

C. Project Record Documents: Record actual locations of components and instrumentation.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: for each type of gauge, thermowell, test plug, and test plug kit from manufacturer.
1.6 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: for each type of gauge, thermowell, test plug, and test plug kit to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS
   A. Extra Temperature and Pressure Gauges: one of each type, range, and size.

1.8 FIELD CONDITIONS
   A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 - PRODUCTS

2.1 PRESSURE GAUGES
   A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      1. Dwyer Instruments, Inc.
      2. Moeller Instrument Co., Inc.
      3. Omega Engineering, Inc.
   B. Direct-Mounted, Dial-Type Pressure Gauges: ASME B40.100, UL 393 drawn steel or cast aluminum case, phosphor bronze bourdon tube, brass or stainless pressure connection with NPS 1/2 threads, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
      1. Dial: Black scale on white background with etched scale markings graduated in psi (kPa).
      2. Size: 4-1/2 inch diameter.
      3. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.
      4. Provide dedicated isolation valve for each insertion well.
   C. Pressure gauge tappings:
      1. Gauge Cock: Tee or lever handle, brass or stainless steel, NPS 1/2 connection for maximum 150 psig.
      2. Needle Valve: Brass or stainless steel, NPS 1/2 connection for minimum 150 psig.
      3. Pulsation Damper: Pressure snubber, brass, ASME B40.100, NPS 1/2 connection, include extensions for use on insulated piping where required.

2.2 THERMOMETERS
   A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      1. Dwyer Instruments, Inc.
      2. Omega Engineering, Inc.
      3. Weksler Glass Thermometer Corp.
   1. Stem length: 3-1/2 inch.
   2. Accuracy: 1 percent of full range or .1 deg F (0.5 deg C), whichever is greater.

C. Thermometer Supports:
   1. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
   2. Flange: 3 inch (75-mm) outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.3 THERMOWELLS

A. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
   2. Type: Stepped shank unless straight or tapered shank is indicated.
   4. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
   5. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
   6. Bore: Diameter required to match thermometer bulb or stem.
   7. Insertion Length: Length required to match thermometer bulb or stem.
   8. Lagging Extension: Include on thermowells for insulated piping and tubing.
   9. Bushings: For converting size of thermowell’s internal screw thread to size of thermometer connection.
   10. Strength: Thermowell shall be designed for a minimum of 35 FPS fluid velocity.

2.4 TEST PLUGS AND TEST PLUG KITS

A. Test Plugs: NPS 1/4 or NPS 1/2 brass or stainless fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with neoprene or EPDM core for 500 psig pressure rating at 200 deg F. Include extended stem where installed on insulated piping.

B. Test Kit: Carrying case, internally padded and fitted containing one 2-1/2 inch diameter pressure gauges, one gauge adapters with 1/8 inch probes, two 1 inch dial thermometers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Install meters and gauges adjacent to machines and equipment to allow service and maintenance of meters, gauges, machines, and equipment.

C. Provide one pressure gauge per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gauge.
D. Install pressure gauges with pulsation dampers. Provide gauge cock to isolate each gauge. Extend nipples and siphons to allow clearance from insulation.

E. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch (64 mm) for installation of thermometer sockets as necessary. Ensure sockets allow clearance from insulation.

F. Install thermometers in air duct systems on flanges.

G. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets. Where thermometers are provided on local panels, duct or pipe mounted thermometers are provided on local panels, duct or pipe mounted thermometers are not required.

H. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes. Ensure thermowells allow clearance from insulation.

I. Fill thermowells with heat-transfer medium.

J. Locate duct mounted thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.

K. Coil and conceal excess capillary on remote element instruments.

L. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

M. Locate test plugs adjacent to thermometers and thermometer sockets. Install test plugs in piping tees.

3.2 ADJUSTING

A. After installation, calibrate meters and gauges according to manufacturer’s written instructions.

B. Adjust faces of meters and gauges to proper angle for best visibility.

3.3 GAUGE SCHEDULE

A. Unless noted otherwise, provide each gauge so that its range exceeds the full operating range of the system it is associated with by 1.5 to 2 times and so that the expected minimum and maximum operating points are within the gauge range.

END OF SECTION
SECTION 23 05 23 - VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Ball valves.
   2. Butterfly valves.
   3. Check valves.

B. Related Sections:
   1. Section 230553 “Identification for HVAC Piping and Equipment”.
   2. Section 232113 “Hydronic Piping”.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer rubber.

C. PTFE: Polytetrafluoroethylene

1.4 ACTION SUBMITTALS

A. See Division 01 and Section 230000 “HVAC General Requirements” for submittal procedures.

B. Product Data: For each type of valve.
   1. Certification that products that come into contact with potable water comply with NSF 61 Annex G and NSF 372.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: for each type of valve to include in operation and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, soldered ends, and grooves.
4. Set butterfly valves closed or slightly open.

B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. Valves shall be manufactured in the United States.

C. Coordinate joint connection with Valve schedule in Part 3 and piping system specifications.
   1. ASME Compliance:
   2. ASME B1.20.1 for threaded end valves.
   3. ASME B16.1 for flanges on iron valves.
   4. ASME B16.5 for flanges on steel valves.
   5. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   7. ASME B31.9 for building service piping valves.

D. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.


F. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

G. Valve Actuator Types:
   1. Gear Actuator: For valves NPS 8 and larger.

H. Valves in Insulated Piping: With 2-inch stem extensions; operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.

I. All plumbing components including but not limited to valves and other wetted parts shall be lead free.
2.2 BALL VALVES

A. Two-Piece, Bronze Ball Valves with Full Port:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. NIBCO INC.
      b. Hammond Valve.
      c. Milwaukee Valve Company.
   2. Description: Two-Piece bronze body, chrome-plated brass ball, bronze trim, PTFE seat, steel handle with plated plastisol coating, 600 psig CWP rating.

B. Steel Ball Valves with Full Port:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. NIBCO INC.
      b. Hammond Valve.
      c. Milwaukee Valve Company.
   2. Description: Carbon steel (ASTM A216) split body, stainless steel ball and stem, PTFE seat.

2.3 BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. NIBCO INC.
      b. Conbraco Industries, Inc.
      c. Hammond Valve.
      d. Milwaukee Valve Company.
      e. DeZURIK.
   2. Description: Cast iron (ASTM A126) or ductile iron (ASTM A536) lug type body, suitable for bidirectional dead-end service at rated pressure without use of downstream flange, EPDM seat, one or two piece stainless steel stem, nickel-plated ductile iron disc.
   3. Standard: MSS SP-67, Type I.

B. Iron, Grooved-End Butterfly Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Victaulic Company.
      b. Kennedy Valve Company; a division of McWane, Inc.
      c. Tyco Fire Products LP.
   2. Description: Coated ductile iron body, EPDM seal, two-piece stainless steel stem, coated ductile iron disc.
   3. Standard: MSS SP-67, Type I.
2.4 CHECK VALVES

A. Bronze, Swing Check Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. NIBCO INC.
      b. Hammond Valve.
      c. Milwaukee Valve Company.
   2. Description: Bronze (ASTM B62) body, spring loaded, bronze disc.

B. Iron Swing Check Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane.
      b. NIBCO INC.
      c. Hammond Valve.
      d. Milwaukee Valve Company.
   2. Description: Gray iron (ASTM A126) body with bolted bonnet, clear or full waterway, spring-loaded, asbestos free gasket, bronze trim, PTFE disc
   3. Standard: MSS SP-71, Type I.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine mating flange faces for damage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

D. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.
E. Install valve tags. Comply with requirements in Section 230553 “Identification for HVAC Piping and Equipment” for valve tags and schedules.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 VALVE SCHEDULE

A. Refer to piping system sections for valve schedules.

B. Coordinate Class or CWP rating with associated piping system rating.
   1. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

END OF SECTION
SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Metal pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Equipment supports.

B. Related Requirements:
   1. Division 05 for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Section 230000 “HVAC General Requirements” for grout.
   3. Section 230516 “Expansion Fittings and Loops for HVAC Piping” for pipe guides and anchors.
   4. Section 230548 “Vibration and Seismic Controls for HVAC” for vibration isolation devices.
   5. Section 233100 “Metal Ducts” for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
   1. Trapeze pipe hangers.
   2. Metal framing systems.
   3. Pipe stands.
   4. Equipment supports.

C. For equipment that is contractor supplied or is substituted for those that are specified, provide structural calculations for equipment anchorage to the structure, sealed and signed by a civil engineer registered in the State of California, demonstrating conformance with section 13.6 of...
ASCE 7-10 (American Society of Civil Engineers) “Minimum Design Loads of Buildings and Other Structures”. Revised equipment anchorage is subject to the review and approval of DSA and shall be submitted by the architect as a Category A CCD.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE


B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

B. Stainless-Steel Pipe Hangers and Supports:
   1. Description: Type 304 Stainless Steel, MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. Metal Framing Systems:
   1. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Channels: Continuous slotted steel channel with inturned lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers:
   1. Pipe Shields Inc.

B. Insulation-Insert Material for Heat Trace Piping: Water-repellent treated, ASTM C533, Type I calcium silicate with 100-psig minimum compressive strength.

C. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

D. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.7 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer’s written instructions.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.


H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   4. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
      b. NPS 4: 12 inches long and 0.06 inch thick.
c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.

6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.
3.6 **HANGER AND SUPPORT SCHEDULE**

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and attachments for general service applications.

F. Use stainless-steel pipe hangers and supports for underground piping.

G. Use thermal-hanger shield inserts for insulated piping and tubing.

H. **Horizontal-Piping Hangers and Supports:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Adjustable, Steel Clevis Hangers (MSS Type 1):** For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. **Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3):** For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
3. **Steel Pipe Clamps (MSS Type 4):** For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
4. **Pipe Hangers (MSS Type 5):** For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
5. **Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6):** For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
6. **Adjustable, Steel Band Hangers (MSS Type 7):** For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
7. **Adjustable Band Hangers (MSS Type 9):** For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. **Adjustable, Swivel-Ring Band Hangers (MSS Type 10):** For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. **Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11):** For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
10. **Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12):** For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
11. **U-Bolts (MSS Type 24):** For support of heavy pipes NPS 1/2 to NPS 30.
12. **Clips (MSS Type 26):** For support of insulated pipes not subject to expansion or contraction.
13. **Pipe Saddle Supports (MSS Type 36):** For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
14. **Pipe Stanchion Saddles (MSS Type 37):** For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
15. **Adjustable Pipe Saddle Supports (MSS Type 38):** For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
16. **Single-Pipe Rolls (MSS Type 41):** For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
17. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
18. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
19. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
20. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

L. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
   2. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   3. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
   4. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
   5. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
   6. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
   7. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
   8. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
   9. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
   10. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
       a. Horizontal (MSS Type 54): Mounted horizontally.
       b. Vertical (MSS Type 55): Mounted vertically.
       c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

M. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

N. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

O. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION
SECTION 23 05 48 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Isolation pads.
   2. Isolation mounts.
   3. Restrained elastomeric isolation mounts.
   4. Freestanding and restrained spring isolators.
   5. Housed spring mounts.
   6. Elastomeric hangers.
   7. Spring hangers.
   8. Spring hangers with vertical-limit stops.
   9. Pipe riser resilient supports.
  10. Resilient pipe guides.
  11. Seismic snubbers.
  12. Restraining braces and cables.
  13. Steel and inertia, vibration isolation equipment bases.

B. Related Sections:
   1. Section 220548 “Vibration and Seismic Controls for Plumbing”.
   2. Section 232113 “Hydronic Piping”.

1.3 REFERENCE STANDARDS


1.4 ACTION SUBMITTALS

A. See Division 01 and Section 230000 “HVAC General Requirements” for submittal procedures.

B. Product Data: Provide schedule of vibration isolator type with location, rated load, rated deflection, load/deflection curve, and overload capacity for each isolation device. Submit
catalog information indicating materials, acoustical performance (if applicable), and dimensional data. Denote exact model number that is to be used cross referenced against equipment tag.

C. For equipment that is contractor supplied or is substituted for those that are specified, provide structural calculations for equipment anchorage to the structure, sealed and signed by a civil engineer registered in the State of California, demonstrating conformance with section 13.6 of ASCE 7-10 (American Society of Civil Engineers) "Minimum Design Loads of Buildings and Other Structures". Revised equipment anchorage is subject to the review and approval of DSA and shall be submitted by the architect as a Category A CCD.

D. Shop Drawings: Indicate inertia bases and locate vibration isolators, with static and dynamic load on each. Indicate seismic control measures. Signed and sealed by a qualified professional structural engineer. Include the following:
1. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base size and weight, equipment static loads, power transmission, component misalignment, and cantilever loads.
3. Seismic-Restraint Details: Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
4. Details for Interlocking Snubbers: Include load deflection curves up to 1/2-inch deflection in x, y, and z planes.

E. Manufacturer’s Instructions: Indicate installation instructions with special procedures and setting dimensions.

1.5 INFORMATIONAL SUBMITTALS
A. Field quality-control reports.
B. Welding certificates.

1.6 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: for each device to include in operation and maintenance manuals.
B. Project Record Documents: Record actual locations of equipment and vibration isolation treatments defined in this section. Record actual locations of hangers including attachment points, loads and static deflection at time of building handover.

1.7 MAINTENANCE MATERIAL SUBMITTALS
A. Extra Temperature and Pressure Gauges: one of each type, range, and size.
1.8 QUALITY ASSURANCE

A. Perform design and installation in accordance with applicable codes.

B. Designer Qualifications: Perform design under direct supervision of a Professional Engineer experienced in design of this type of work and registered and licensed in the State in which the Project is located.

C. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.

D. Installer Qualifications: Company specializing in performing Work of this section with not less than three years of documented experience.


PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Kinetics Noise Control, Inc.

B. Mason Industries.

C. Vibration Mountings & Controls, Inc.

2.2 PERFORMANCE REQUIREMENTS

A. All vibration isolators, base frames and inertia bases to conform to all uniform deflection and stability requirements under all operating loads.

B. Steel springs shall function without undue stress or overloading.

C. All equipment mounted on vibration isolated bases to have minimum operating clearance of 2 inches between the base and floor or support beneath unless noted otherwise.

2.3 EQUIPMENT SUPPORT BASES

A. Structural Bases [SB]:
   1. Construction: Engineered, structural steel frames with welded brackets for side mounting of the isolators.
   2. Frames: Square, rectangular or T-shaped.
   3. Design: Sufficiently rigid to prevent misalignment or undue stress on machine, and to transmit design loads to isolators and snubbers.

B. Concrete Inertia Bases [CIB]:
   1. Mass: Minimum of 1.5 times weight of isolated equipment.
2. Construction: Structured steel channel perimeter frame, with gusset brackets and anchor bolts, adequately reinforced, concrete filled.
3. Connecting Point: Reinforced to connect isolators and snubbers to base.
4. Concrete: Reinforced 3,000 psi (20 MPa) concrete.
5. Bases for pumps shall be large enough to provide support for suction and discharge elbows.
6. The base depth shall be a minimum of 1/12th of the longest dimension of the base, but not less than 6 inches. The base depth need not exceed 12 inches unless specifically recommended by the base manufacturer for mass or rigidity.
7. Forms shall include minimum concrete reinforcement consisting of half-inch bars or angles welded in place on 6 inch centers running both ways in a layer 1-1/2 inches above the bottom, or additional steel members to hold anchor-bolt sleeves when the anchor bolts fall in concrete locations.
8. Height saving brackets shall be employed in all mounting locations to maintain a minimum 2 inch clearance below the base.
9. Basis of design: Mason “K”.

2.4 VIBRATION ISOLATORS

A. Neoprene Pad Isolators [NP]:
   1. Rubber or neoprene-waffle pads.
   2. Durometer to achieve static deflection as specified.
   3. Minimum 1/2 inch thick.
   4. Maximum loading 40 psi
   5. Height of ribs: not to exceed 0.7 times width.
   6. Configuration: 1/2 inch thick waffle pads bonded each side of 1/4 inch (6 mm) thick steel plate.
   7. Basis of design: Mason “WM”.

B. Open Free-Standing Spring Isolators [FS]:
   1. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
   2. Color code springs for load carrying capacity.
   3. Springs: Minimum horizontal stiffness equal to 100 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
   4. Free standing and laterally stable spring isolators (single or multiple steel springs) without any housing and complete with 1/4 inch neoprene acoustical pads between the base plate and the support.
   5. Spring diameter shall be no less than 0.8 of the compressed height of the spring at design load.
   6. Spring Mounts: Furnish with leveling devices, minimum 0.25 inch thick neoprene sound pads, and zinc chromate plated hardware.
   7. Sound Pads: Size for minimum deflection of 0.05 inch; meet requirements for neoprene pad isolators.
   8. Provide all mountings with leveling bolts, rigidly bolted to the equipment.
   9. Provide height saving mounting brackets where applicable, height adjustment bolts.
   10. Basis of design: Mason “SLF”.

C. Restrained Spring Isolators [RS]:
   1. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
   2. Color code springs for load carrying capacity.
   3. Springs: As in type FS.
4. Spring Mounts: As in type FS.
5. Sound Pads: As in type FS.
6. Restraint: Furnish mounting frame and limit stops. A minimum 1/2 inch clearance shall be maintained around the restraint bolts, housings, and springs so as not to interfere with the spring action.
7. Basis of design: Mason “SLR”.

D. Riser Clamp Pad [RP]:
1. Resilient pad between riser clamp and support structure to eliminate rigid contact.
2. Basis of Design: Regufoam, Armaflex or approved equivalent.

E. Spring Hanger [SH]
1. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
2. Color code springs for load carrying capacity.
5. Misalignment: Capable of 30 degree arc before contacting hanger housing.
6. Basis of design: Mason “30N”.

F. Neoprene Hangers [NH]:
1. Molded neoprene units in a steel hanger frame.
2. Double deflection types with static deflection range from 0.3 to 0.5 inch.
3. Designed to preclude contact of hanger rods with frame (30 degrees misalignment). Insert neoprene bushing where rod passes through housing.
4. Basis of design: Mason “HD”.

G. Thrust Restraints:
1. Thrust restraint shall consist of a spring element in series with a neoprene pad. The unit shall be designed to have the same deflection as specified for the isolators supporting the equipment. The spring element shall be contained within a steel frame and be designed so it can be preset at the factory for thrust and be adjusted in the field to allow for a maximum of 1/4 inch movement during starting or stopping of the equipment.
2. The assembly shall be furnished complete with rods and angle brackets for attachment to both the equipment and the adjacent fixed structural anchor.
3. Thrust restraints shall be provided for all equipment as follows:

<table>
<thead>
<tr>
<th>Spring Isolator Deflection</th>
<th>Thrust</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 inches or more</td>
<td>Greater than 5% of equipment weight</td>
</tr>
<tr>
<td>2 inches</td>
<td>Greater than 10% of equipment weight</td>
</tr>
<tr>
<td>1 inch</td>
<td>Greater than 15% of equipment weight</td>
</tr>
</tbody>
</table>

Note: Equipment weight includes all isolated items including vibration isolation base.
4. Height saving brackets shall be employed in all mounting locations to maintain a minimum 2 inch clearance below the base.
5. Basis of design: Mason “WB”.

2.5 SEISMIC SNUBBER ASSEMBLIES

A. Comply with:
1. ASHRAE Handbook – HVAC Applications
2. SMACNA – Seismic Duct Restraint Manual
B. All Directional External:
   1. Application: Minimum three (3) snubbers are required for each equipment installation, oriented properly to restrain isolated equipment in all directions.
   2. Construction: Interlocking steel construction attached to the building structure and equipment in a manner consistent with anticipated design loads.
   3. Performance: Equipment movement at each snubber location limited to a maximum of 0.25 inches in any direction without significantly degrading the vibration isolation capability of the isolator during normal operating conditions.
   4. Resilient Pad: Minimum 0.25 inch thick cushions any impact and prevents metal-to-metal contact.

C. Lateral External:
   1. Application: Minimum three (3) snubbers are required for each stable equipment installation, oriented properly to restrain isolated equipment in all lateral directions where uplift forces are zero or addressed by other restraints.
   2. Construction: Steel construction attached to the building structure and equipment in a manner consistent with anticipated design loads.
   3. Performance: Equipment movement at each snubber location limited to a maximum of 0.25 inches in any direction without significantly degrading the vibration isolation capability of the isolator during normal operating conditions.
   4. Resilient Pad: Minimum 0.25 inch thick cushions any impact and prevents metal-to-metal contact.

2.6 SEISMIC RESTRAINTS FOR SUSPENDED COMPONENTS AND EQUIPMENT

A. Comply with:
   1. ASHRAE Handbook – HVAC Applications
   2. SMACNA – Seismic Duct Restraint Manual

B. Cable Restraints:
   1. Wire Rope: Steel wire strand cables sized to resist seismic loads in all lateral directions.
   3. Size: Based on the lesser of cable capacity or anchor load taking into account bracket geometry.
   4. Connections:
   5. Use overlapping wire rope U clips, cable clamping bolts, swaged sleeves or seismically rated tool-less wedge insert lock connectors.
   6. Internally brace clevis hanger bracket cross bolt to prevent deformation.
   7. Vertical Suspension Rods: Attach required bracing of sufficient strength to prevent rod buckling from vertical compression forces utilizing series of attachment clips.

C. Rigid Restraints:
   1. Structural Element: Sized to resist seismic loads in all lateral directions and carry both compressive and tensile loading.
   2. Size: Based on the lesser of cable capacity or anchor load taking into account bracket geometry.
   3. Connections: Internally brace clevis hanger bracket cross bolt to prevent deformation.
   4. Static Support System: Anchorage capable of carrying additional tension loads generated by the vertical component of the rigid brace compression which is additive to any static load requirements on the system.
   5. Vertical Suspension Rods: Attached required bracing of sufficient strength to prevent rod buckling from vertical compression forces utilizing series of attachment clips.
2.7 ACCESSORIES

A. Flexible pipe connectors:
   1. Manufacturers:
      a. Metraflex.
      b. Keflex.
      c. Mason.
   2. Steel Piping:
      a. Inner Hose: Carbon Steel
      c. Pressure Rating: 125 psig WSP and 450 deg F.
      d. Joint: Flanged.
      e. Size: Match pipe-size.
      f. Maximum offset: 1 inch on each side of installed centerline.
   3. Copper Piping:
      a. Inner Hose: Bronze
      b. Exterior Sleeve: Braided bronze.
      c. Pressure Rating: 125 psig WSP and 450 deg F.
      d. Joint: Threaded with brass fittings.
      e. Size: Match pipe size.
      f. Maximum offset: 1 inch on each side of installed center line.
   4. Pipework flexible connections shall be manufactured of multiple plies of nylon tire cord fabric and neoprene both molded and cured in hydraulic rubber presses. No steel wire or rings shall be used as pressure reinforcement. 1-1/2 in. Straight connectors shall have two spheres. Connectors up to and including 1-1/2 in. diameter may have threaded ends. Connectors 2 in. and larger shall be manufactured with floating galvanized flanges recessed to lock the connector’s raised face neoprene flanges.
   5. Hoses shall be installed on the equipment side of the shut valves.
   6. Basis of Design: Elbows shall be Mason-Flex “MFNEC”, straight connectors shall be Mason-Flex “MFTFU” or “MFTNC”, and control cable assemblies Mason “ACC”.

PART 3 - EXECUTION

3.1 INSTALLATION – GENERAL

A. Install in accordance with manufacturer’s instructions.
B. Adjust equipment level.
C. Install spring hangers without binding.
D. Provide a minimum of 1” clearance between the building structure (walls, floors, and ceilings) and vibration isolated supports, ducts, pipes, and equipment.
E. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.
F. Provide pairs of thrust restraint horizontal limit springs on fans based on static pressure as scheduled.

G. Do not use vibration isolation components to straighten or connect misaligned sections of piping or ductwork.

H. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

I. The installation or use of vibration isolators must not cause any change in position of equipment, piping, or ducts that result in stresses in any connections or misalignment of shafts or bearings. Equipment shall be maintained in a rigid position during installation. The load shall not be transferred to the isolators until the installation is complete and in operational condition.

J. Do not install any mechanical equipment, ducts, or piping that makes rigid contact with the “building” unless it is approved in this specification or by the Engineer. “Building” includes, but is not limited to, slabs, beams, columns, walls, partitions, ceilings, studs, ceiling framing, and suspension systems. Resiliently-isolated piping shall not contact building construction or other equipment or items.

K. Align isolation hanger rods to clear the hanger box under all operating conditions.

L. Level vibration isolated equipment under rated design operating conditions while maintaining the isolation criteria. Isolators shall be plumb and aligned to preclude misalignment or undesired contact during operation.

3.2 INSTALLATION – SEISMIC

A. Seismic Snubbers:
   1. Provide on all isolated equipment, piping and ductwork.
   2. Provide minimum of four seismic snubbers located close to isolators.
   3. Snub equipment designated for post-disaster use to 0.05 inch maximum clearance.
   4. Snub all other equipment between 0.15 inch and 0.25 inch clearance.

B. Floor and Base-Mounted Equipment, Vibration Isolated Equipment and associated Vibration and Seismic Controls for Connections:
   1. Install equipment anchorage items designed to resist seismic design force in any direction.
   2. Install vibration and seismic controls designed to include base and isolator requirements.
   3. Provide flexible connections between equipment and interconnected piping.
   4. Provide isolators and restraints designed for amplified code forces per ASCE 7 and with demonstrated ability to resist required forces including gravity, operational and seismic forces.

C. Suspended Mechanical Equipment:
   1. Provide supports and bracing to resist seismic design force in any direction.
   2. Provide flexible connections between equipment and interconnected piping.
   3. Brace equipment hung from spring mounts using cable or other bracing that will not transmit vibration to the structure.
4. Use of proprietary restraint systems with a certificate of compliance, verified and listed by an accredited inspection body is acceptable (pending shop drawing approval), as an alternative to project specific seismic bracing design.

D. Wall mounted Mechanical Equipment:
1. Provide support and bracing to resist seismic design force in any direction.
2. Install backing plates or blocking as required to deliver load to primary wall framing members.
3. Anchoring to gypsum wallboard, plaster or other wall finish that has not been engineered to resist imposed loads is not permitted.

E. Piping:
1. Provide seismic bracing in accordance ASC 7.
2. Provide supports, braces, and anchors to resist gravity and seismic design forces.
3. Provide flexible connections between floor-mounted equipment and suspended piping; between unbraced piping and restrained suspended items; as required for thermal movement; at building separations and seismic joints; and wherever relative differential movements could damage pipe in an earthquake.
4. Brace resiliently supported pipe with cable bracing or alternate means designed to prevent transmission of vibrations and noise to the structure.
5. Brace every run 5.0 feet or more in length with two transverse and one longitudinal bracing locations.
6. Pipes and Connections Constructed of Ductile Materials (copper, ductile iron, steel or aluminum and brazed, welded or screwed connections):
   a. Provide transverse bracing at spacing not more than 40.0 feet on center.
   b. Provide longitudinal bracing at spacing not more than 80.0 feet on center.
7. Pipes and Connections Constructed of Non Ductile Materials (cast iron, no-hub, plastic or non-UL Listed grooved coupling pipe):
   a. Provide transverse bracing at spacing not more than 20.0 feet on center.
   b. Provide longitudinal bracing at spacing not more than 40.0 feet on center.
   c. Provide lateral restraint for risers at not more than 30 feet on center or as required for horizontal runs, whichever is less.
8. Piping Explicitly Exempt from Seismic Bracing Requirements:
   a. Provide flexible connections between piping and connected equipment, including in-line devices such as VAV boxes and reheat coils.
   b. Install piping consistent with ASCE 7, such that swinging of the pipes will not cause damaging impact with adjacent components, finishes, or structural framing while maintaining clear horizontal distance of 67 percent of the hanger length between subject components.
   c. Provide swing restraints as required to control potential impact due to limited space between subject components.
9. Use of proprietary restraint systems with a certificate of compliance, verified and listed by an accredited inspection body is acceptable (pending shop drawing approval), as an alternative to project specific seismic bracing design.

F. Ductwork:
1. Provide seismic bracing for ducts with cross sectional area greater than 6 sq ft (independent of duct contents).
2. Provide seismic bracing for all ducts containing hazardous materials.
3. Provide supports, braces, and anchors to resist gravity and seismic design forces.
4. Independently support in-line devices weighing more than 20 pounds.
5. Independently support and brace all in-line devices weighing more than 75 pounds.  
6. Provide unbraced piping attached to braced in-line equipment with adequate flexibility to accommodate differential displacements.  
7. Positively attach dampers, louvers, diffusers and similar appurtenances to ductwork with mechanical fasteners.  
8. Install duct supports designed to resist not less than 150 percent of the duct weight.  
9. The use of power driven fasteners is prohibited in the hanging of ducts weighing over 10 pounds per lineal foot for seismic design categories D, E, and F.  
10. Use of proprietary restraint systems with a certificate of compliance, verified and listed by an IAS AC172 accredited inspection body or otherwise accepted by applicable codes is acceptable (pending shop drawing approval), as an alternative to project specific seismic bracing design.

G. Tanks:  
1. Install tank anchorage, tank legs and/or supporting structure designed to resist design force.  
2. Provide flexible connections between tank and interconnected piping.

3.3 INSTALLATION – VIBRATION ISOLATING EQUIPMENT

A. Flexible Pipe Connections:  
1. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.  
2. Use flexible double sphere neoprene pipe connectors for connections to pumps on vibration isolators.  
3. Use flexible wire braided connectors on branch connections to heat transfer equipment.  
4. Install flexible connectors to accommodate displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.

B. Pipe and Duct Supports:  
1. Isolate all pipes & ducts attached to the inlet and discharge of spring-isolated equipment and pressure-reducing valves using the same isolator type and static deflection as the equipment isolators within the mechanical room or 50 feet (whichever is greater) from the inlet and discharge.  
2. Isolate the remainder of horizontal pipe runs 2-in in diameter and greater using Type NM or NH isolators.  
3. All vertical risers for piping 2-in diameter or greater shall be isolated from the building structure by means of guides, supports, and spring isolators. The support systems shall be an engineered solution taking into account pipe movement, expansion and vibration isolation.  
4. All vertical risers for piping less than 2-in diameter shall be isolated from the building structure by Type NM neoprene mount below flanges or pipe clamps. Where fixing to structure is required, neoprene isolator bushings shall be used to provide resilient support.

C. Bases:  
1. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 03.  
2. Set steel bases for 1 inch clearance between housekeeping pad and base.  
3. Set concrete inertia bases for 2 inch clearance between housekeeping pad and base.
D. Install isolation for motor driven equipment.

3.4 FIELD QUALITY CONTROL
A. Inspect isolated equipment after installation and submit report. Include static deflections.
B. Inspect isolator seismic-restraint clearance.
C. Test isolator deflection.
D. Inspect minimum snubber clearances.

3.5 ADJUSTING
A. Adjust isolators after piping systems have been filled and equipment is at operating weight.
B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop.

3.6 SCHEDULE

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Isolator Type</th>
<th>Minimum Static Deflection (in)</th>
<th>Bases</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumps (close-coupled)</td>
<td>FS</td>
<td>2</td>
<td>CIB</td>
<td></td>
</tr>
<tr>
<td>Air-source heat pumps</td>
<td>FS</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air handling unit fans (internal isolation)</td>
<td>FS</td>
<td>2</td>
<td></td>
<td>Provided by unit manufacturer</td>
</tr>
<tr>
<td>Centrifugal fans less than 22 in. diameter wheel – base mounted</td>
<td>FS</td>
<td>1</td>
<td>SB</td>
<td></td>
</tr>
<tr>
<td>Centrifugal fans greater than 22 in. diameter wheel, base mounted</td>
<td>FS</td>
<td>2</td>
<td>SB</td>
<td></td>
</tr>
<tr>
<td>Fan coil units and other ducted rotating small equipment – suspended</td>
<td>FS</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Duct labels.
   5. Stencils.
   6. Valve tags.
   7. Warning tags.

1.3 ACTION SUBMITTALS
A. Product Data: For each type of product.
B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
C. Valve numbering scheme.
D. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS
A. Metal Labels for Equipment:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Kolbi Pipe Marker Co.
      c. Seton Identification Products.
   2. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   4. Background Color: Black.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

B. Plastic Labels for Equipment:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Kolbi Pipe Marker Co.
   c. Seton Identification Products.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

C. Label Content: Include equipment’s Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Marking Services Inc.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.

D. Background Color: Yellow.
E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.


I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Kolbi Pipe Marker Co.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: Size letters according to ASME A13.1 for piping and at least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.4 DUCT LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Kolbi Pipe Marker Co.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

C. Maximum Temperature: Able to withstand temperatures up to 140 deg F.
D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

F. Fasteners: Stainless-steel self-tapping screws.

G. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.5 STENCILS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brimar Industries, Inc.
   2. Kolbi Pipe Marker Co.
   3. Marking Services Inc.

B. Lettering Size: Size letters according to ASME A13.1 for piping and at least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

C. Stencil Material: Brass.

D. Stencil Paint: Exterior, gloss, acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

E. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

2.6 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Kolbi Pipe Marker Co.

B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link chain or beaded chain or S-hook.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
   1. Size: Approximately 4 by 7 inches.
   2. Fasteners: Brass grommet and wire.
   3. Nomenclature: Large-size primary caption such as “DANGER,” “CAUTION,” or “DO NOT OPERATE.”

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Division 09.

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer’s option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.
   1. Identification Paint: Use for contrasting background.
C. **Pipe Label Locations:** Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

D. **Directional Flow Arrows:** Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

E. **Pipe Label Color Schedule:** follow ASME A13.1.

### 3.5 DUCT LABEL INSTALLATION

A. Install plastic-laminated duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For supply ducts.
2. Yellow: For exhaust ducts.

B. **Stenciled Duct Label Option:** Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer’s option.

C. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

### 3.6 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. **Valve-Tag Application Schedule:** Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. **Valve-Tag Size and Shape:** 1-1/2 inches, round.
2. **Valve-Tag Colors:** follow ASME A13.1.
3.7  WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION
SECTION 230593 - TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Testing, adjustment, and balancing of air systems.
B. Testing, adjustment, and balancing of hydronic systems.
C. Testing, adjustment, and balancing of refrigeration systems.
D. Measurement of final operating condition of HVAC systems.
E. Measuring electrical performance of HVAC equipment.
F. Setting quantitative performance of HVAC equipment.
G. Verifying that automatic control devices are functioning properly.
H. Sound measurement of equipment operating conditions.
I. Vibration measurement of equipment operating conditions.
J. Reporting results of activities and procedures specified in this Section.
K. Commissioning activities.

1.2 REFERENCE STANDARDS


1.3 DEFINITIONS

B. CAV: Constant air volume.
C. cfm: Cubic feet per minute.
E. NC: Noise criteria.
F. TAB: Testing, adjusting, and balancing.
G. VAV: Variable air volume.

1.4 SUBMITTALS

A. See Division 01 for submittal procedures.

B. LEED Submittals:
   1. Air-Balance Report for Prerequisite IEQ 1: Documentation indicating that work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
   2. TAB Report for Prerequisite EA 2: Documentation indicating that work complies with ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

C. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
   1. Submit to the Commissioning Authority.
   2. Submit six weeks prior to starting the testing, adjusting, and balancing work.
   3. Include certification that the plan developer has reviewed the contract documents, the equipment and systems, and the control system with the Architect and other installers to sufficiently understand the design intent for each system.
   4. Include at least the following in the plan:
      a. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
      b. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
      c. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
      d. Final test report forms to be used.
      e. Detailed step-by-step procedures for TAB work for each system and issue, including:
         1) Terminal flow calibration (for each terminal type).
         2) Diffuser proportioning.
         3) Branch/submain proportioning.
         4) Total flow calculations.
         5) Rechecking.
         6) Diversity issues.
      f. Expected problems and solutions, etc.
      g. Criteria for using air flow straighteners or relocating flow stations and sensors; analogous explanations for the water side.
      h. Details of how TOTAL flow will be determined; for example:
         1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
         2) Water: Pump curves, circuit setter, flow station, ultrasonic, etc.
i. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and methods to verify this.

j. Confirmation of understanding of the outside air ventilation criteria under all conditions.

k. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).

l. Method of checking building static and exhaust fan and/or relief damper capacity.

m. Methods for making coil or other system plant capacity measurements, if specified.

n. Time schedule for TAB work to be done in phases (by floor, etc.).

o. Description of TAB work for areas to be built out later, if any.

p. Time schedule for deferred or seasonal TAB work, if specified.

q. False loading of systems to complete TAB work, if specified.

r. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.

s. Interstitial cavity differential pressure measurements and calculations, if specified.

t. Procedures for field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).

u. Procedures for formal progress reports, including scope and frequency.

v. Procedures for formal deficiency reports, including scope, frequency and distribution.

D. Field Logs: Submit at least twice a week to Commissioning Authority.

E. Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect, or could affect, the control system setup and operation.

F. Progress Reports.

1. As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

G. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

1. Submit under provisions of Division 01.

2. Submit to the Commissioning Authority within two weeks after completion of testing, adjusting, and balancing.

3. Revise TAB plan to reflect actual procedures and submit as part of final report.

4. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect and for inclusion in operating and maintenance manuals.

5. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

6. Include actual instrument list, with manufacturer name, serial number, and date of calibration.

7. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing agent.

8. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std. 111.

9. Units of Measure: Report data in both I-P (inch-pound) and SI (metric) units.

10. Include the following on the title page of each report:

a. Name of Testing, Adjusting, and Balancing Agency.
b. Address of Testing, Adjusting, and Balancing Agency.
c. Telephone number of Testing, Adjusting, and Balancing Agency.
d. Project name.
e. Project location.
f. Project Architect.
g. Project Engineer.
h. Project Contractor.
i. Project altitude.
j. Report date.

11. In addition to certified field report data, include the following:
   a. Pump curves.
   b. Fan curves.
   c. Manufacturers’ test data.
   d. Field quality-control test reports prepared by system and equipment installers.
   e. Other information relative to equipment performance, but do not include approved Shop Drawings and Product Data.

12. Signature of testing, adjusting, and balancing Agent who certifies the report.

13. Summary of contents, including the following:
   a. Design versus final performance.
   b. Notable characteristics of systems.
   c. Description of system operation sequence if it varies from the Contract Documents.

14. Notes to explain why certain final data in the body of reports vary from design values.

15. Test conditions for fans and pump performance forms, including the following:
   a. Settings for outside-, return-, and exhaust-air dampers.
   b. Conditions of filters.
   c. Cooling coil, wet- and dry-bulb conditions.
   d. Face and bypass damper settings at coils.
   e. Fan drive settings, including settings and percentage of maximum pitch diameter.
   f. Settings for supply-air, static-pressure controller.
   g. Other system operating conditions that affect performance.

16. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present with single-line diagrams and include the following:
   a. Quantities of outside, supply, return, and exhaust airflows.
   b. Water flow rates.
   c. Duct, outlet, and inlet sizes.
   d. Pipe and valve sizes and locations.
   e. Terminal units.
   f. Balancing stations.

17. Noise and Vibration Measurement Tests: Performed in accordance with ASHRAE handbook guidelines and only after air and water balance is complete. Noise measurements should be reported in octave bands and overall NC rating by space.

18. Title 24 Acceptance Tests: Perform all functions and tests required by Title 24 acceptance tests. Identify and make any system adjustments to achieve acceptance testing objectives. Complete acceptance testing forms and submit to Engineer and General Contractor.

H. Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.
PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 QUALITY ASSURANCE

A. Agent Qualifications: Engage a testing, adjusting, and balancing agent certified by AABC.

B. Certification of Testing, Adjusting, and Balancing Reports: Certify testing, adjusting, and balancing field data reports. This certification includes the following:
   1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.
   2. Certified that testing, adjusting, and balancing team complied with approved testing, adjusting, and balancing plan and procedures specified and referenced in this Specification.

C. Testing, Adjusting, and Balancing Reports: Use standard forms from AABC’s “National Standards or Testing, Adjusting and Balancing.”

D. Instrumentation Type, Quantity and Accuracy: As described in AABC national standards.

E. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by the instrument manufacturer.

3.2 PROJECT CONDITIONS

A. Partial Owner Occupancy: The Owner may occupy completed areas of the building before Substantial Completion. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner’s operations.

3.3 COORDINATION

A. Coordinate efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting, and balancing activities.

B. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

C. If another round of pressure testing of the raised floor assembly is required after the first testing, verify that all trades have completed their work to mitigate areas of leakage before commencing additional test.

3.4 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC’S “National Standards” forms stating that AABC will assist in completing the requirements of the Contract Documents if the testing, adjusting, and balancing Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:
B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing the requirements of the Contract Documents if the testing, adjusting, and balancing Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified Agent has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

3.5 GENERAL REQUIREMENTS

A. Perform total system balance in accordance with one of the following:

1. AABC MN-1, AABC National Standards for Total System Balance.
5. Maintain at least one copy of the standard to be used at project site at all times.

B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.

C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.

D. TAB Agency Qualifications:

1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
2. Having minimum of three years documented experience.

E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

F. TAB Supervisor Qualifications: Professional Engineer licensed in California.

3.6 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:

1. Examine the Contract Documents to become familiar with project requirements and to discover conditions in systems’ designs that may preclude proper testing, adjusting, and balancing of systems and equipment.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
3. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
4. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible and their controls are connected and functioning.
5. Examine plenum ceilings, utilized for supply air, to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

6. Systems are started and operating in a safe and normal condition.

7. Temperature control systems are installed complete and operable.

8. Proper thermal overload protection is in place for electrical equipment.

9. Final filters are clean and in place. If required, install temporary media in addition to final filters.

10. Duct systems are clean of debris.

11. Fire and volume dampers are in place and open.

12. Air coil fins are cleaned and combed.

13. Examine open-piping-system pumps to ensure absence of entrained air in suction piping.

14. Examine equipment for installation and for properly operating safety interlocks and controls.

15. Access doors are closed and duct end caps are in place.

16. Air outlets are installed and connected.

17. Duct system leakage is minimized.

18. Hydronic systems are flushed, filled, and vented.

19. Pumps are rotating correctly.

20. Proper strainer baskets are clean and in place.

21. Service and balance valves are open.

22. Examine equipment performance data, including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, “Fans and Systems,” Sections 7 through 10; or in SMACNA’s “HVAC Systems--Duct Design,” Sections 5 and 6. Compare this data with design data and installed conditions.

23. Examine automatic temperature system components to verify the following:

   a. Dampers, valves, and other controlled devices operate by the intended controller.
   b. Dampers and valves are in the position indicated by the controller.
   c. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
   d. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
   e. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
   f. Sensors are located to sense only intended conditions.
   g. Sequence of operation for control modes is according to the Contract Documents.
   h. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
   i. Interlocked systems are operating.
   j. Changeover from heating to cooling mode occurs according to design values

B. Examine installed raised floor assembly prior to testing. Identify and key areas that are likely to cause excessive air leakage and report deficiencies discovered before and during performance of air leakage testing. Repeat examination prior to start of any additional pressure testing. Perform similar examination of mockup prior to start of pressure testing of mock-up.

C. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.

D. Beginning of work means acceptance of existing conditions.
3.7 PREPARATION

A. Hold a pre-balancing meeting at least one week prior to starting TAB work.
   1. Require attendance by all installers whose work will be tested, adjusted, or balanced.

B. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect to facilitate spot checks during testing.

C. Provide additional balancing devices as required.

D. Complete system readiness checks and prepare system readiness reports. Verify the following:
   1. Permanent electrical power wiring is complete.
   2. Hydronic systems are filled, clean, and free of air.
   3. Automatic temperature-control systems are operational.
   4. Equipment and duct access doors are securely closed.
   5. Balance, smoke, and fire dampers are open.
   6. Isolating and balancing valves are open and control valves are operational.
   7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
   8. Windows and doors can be closed so design conditions for system operations can be met

3.8 ADJUSTMENT TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.9 RECORDING AND ADJUSTING

A. Field Logs: Maintain written logs including:
   1. Running log of events and issues.
   2. Discrepancies, deficient or uncompleted work by others.
   4. Lists of completed tests.

B. Ensure recorded data represents actual measured or observed conditions.

C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

D. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
F. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

G. Check and adjust systems approximately six months after final acceptance and submit report.

3.10 GENERAL PROCEDURES

A. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.

B. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.11 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

C. Measure air quantities at air inlets and outlets.

D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

K. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.
L. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.

M. Check multi-zone units for motorized damper leakage. Adjust air quantities with mixing dampers set first for cooling, then heating, then modulating.

N. For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

O. On fan powered VAV boxes, adjust air flow switches for proper operation.

3.12 WATER SYSTEM PROCEDURE

A. Adjust water systems to provide required or design quantities.

B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.

C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

D. Effect system balance with automatic control valves fully open to heat transfer elements.

E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

G. Hydronic system flows shall be balanced at the pump by setting the appropriate frequency on the Variable Frequency Drive. Under no circumstances shall it be acceptable to balance a pump or system flow by throttling or turning down an isolation valve at the pump. Hydronic system balancing shall occur with pump isolation valves at their full 100 percent open position.

H. Flow across control valves shall be measured by means of two sample ports (Pete’s Plugs) located immediately adjacent to the inlet and outlet, respectively, of the control valve. These ports shall be used to obtain the pressure drop across the control valve at its full open position. The control valve Cv shall then be used to calculate the flow rate through the valve. The manual shutoff valve shall be used to provide balance throttling only where necessary and required by the design, with the balanced position noted by a permanent mark spanning from the valve handle to stationary valve body.

3.13 SOUND AND VIBRATION TESTS

A. Perform sound and vibration tests after air and water balance is complete. Measurements should be performed with HVAC and plumbing equipment on and HVAC and plumbing equipment off.
### 3.14 ADDITIONAL TESTS

A. Within 90 days of completing testing, adjusting, and balancing, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial testing, adjusting, and balancing procedures were not performed during near-peak summer and winter conditions, perform additional inspections, testing, and adjusting during near-peak summer and winter conditions.

### 3.15 COMMISSIONING

A. Perform prerequisites prior to starting commissioning activities.

B. Fill out Prefunctional Checklists for:
   1. Air side systems.
   2. Water side systems.

C. Furnish to the Commissioning Authority, upon request, any data gathered but not shown in the final TAB report.

D. Re-check minimum outdoor air intake flows and maximum and intermediate total airflow rates for all of the air handlers.
   1. Original TAB agency shall execute the re-checks, witnessed by the Commissioning Authority.
   2. Use the same test instruments as used in the original TAB work.
   3. Failure of more than 10 percent of the re-checked items of a given system shall result in the rejection of the system TAB report; rebalance the system, provide a new system TAB report, and repeat random re-checks.
   4. For purposes of re-check, failure is defined as follows:
      a. Air Flow of Supply and Return: Deviation of more than 10 percent of instrument reading.
      b. Minimum Outside Air Flow: Deviation of more than 20 percent of instrument reading; for inlet vane or VFD OSA compensation system using linear proportional control, deviation of more than 30 percent at intermediate supply flow.
      c. Temperatures: Deviation of more than one deg F.
      d. Air and Water Pressures: Deviation of more than 10 percent of full scale of test instrument reading.
   5. For purposes of re-check, a whole system is defined as one in which inaccuracies will have little or no impact on connected systems; for example, the air distribution system served by one air handler or the hydronic chilled water supply system served by a chiller or the condenser water system.

E. In the presence of the Commissioning Authority, verify that:
   1. Final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked.
   2. The air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all terminal units taking off
downstream of the static pressure sensor, the terminal unit on the critical leg has its damper 90 percent or more open.

3. The water system is being controlled to the lowest possible pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from the pump to the coil having all balancing valves wide open and that during full cooling the cooling coil valve of that leg is 90 percent or more open.

F. No seasonal tests are required.

G. No further monitoring is required.

H. No deferred testing is required.

3.16 MINIMUM DATA TO BE REPORTED

A. General:

1. A certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. A list of instruments used for procedures, along with proof of calibration.
3. Nomenclature sheets for each item of equipment.
4. Notes to explain why certain final data in the body of reports vary from indicated values.
5. Description of system operation sequence if it varies from the Contract Documents.
7. Design and actual values for measurements below.

B. Testing Instruments:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

C. Air Handling Units:

1. Total airflow rate in cfm.
2. Total system static pressure in inches wg.
3. Fan rpm.
4. Discharge static pressure in inches wg.
5. Filter static-pressure differential in inches wg.
7. Outdoor airflow in cfm.
8. Return airflow in cfm.
10. Return-air damper position.

D. Electric Motors:

1. Model/Frame
2. HP/BHP
3. Phase, voltage, amperage; nameplate, actual, no load
4. RPM
5. Service factor
6. Starter size, rating, heater elements
7. Sheave Make/Size/Bore

E. V-Belt Drives:
   1. Identification/location
   2. Required driven RPM
   3. Driven sheave, diameter and RPM
   4. Belt, size and quantity
   5. Center to center distance, maximum, minimum, and actual

F. Ducts:
   1. System and air-handling-unit number.
   2. Location and zone.
   3. Traverse air temperature in deg F.
   4. Duct static pressure in inches wg.
   5. Duct size in inches.
   6. Duct area in sq. ft.
   7. Airflow rate in cfm.
   8. Velocity in fpm.

G. Pumps:
   1. Identification/number
   2. Manufacturer
   3. Size/model
   4. Impeller
   5. Service
   6. Design flow rate, pressure drop, BHP
   7. Actual flow rate, pressure drop, BHP
   8. Discharge pressure
   9. Suction pressure
   10. Total operating head pressure
   11. Shut off, discharge and suction pressures
   12. Shut off, total head pressure

H. Vibration Tests

I. Other Equipment:
   1. Model number
   2. Serial number
   3. Rated capacity

END OF SECTION
SECTION 230713 - HVAC DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary
Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Duct insulation.
   2. Fire-rated insulation.
   3. Insulation jackets.

B. Related Sections:
   2. Division 07 - Firestopping.
   3. Division 09 - Painting and Coating: Painting insulation jackets.
   4. Section 230553 - Identification for HVAC Piping and Equipment.
   5. Section 233100 – HVAC Metal Ducts

1.3 REFERENCE STANDARDS


D. ASTM C553 - Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and
Industrial Applications; 2013.

E. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation;
2014.

F. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation; 1985
(Reapproved 2007).

G. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and
Sound Absorbing Material); 2012.

H. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to
Externally Insulate HVAC Ducts; 2011.


1.4 ACTION SUBMITTALS

A. See Division 01 and Section 230000 “HVAC General Requirements” for submittal procedures.

B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

C. LEED Submittals: Product Data for compliance with VOC content.

D. Manufacturer's Instructions: Indicate installation procedures which ensure acceptable workmanship and installation standards will be achieved. Include details for removable insulation sections at access panels.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.

B. Applicator Qualifications: Company specializing in performing the type of work specified in this section, with minimum five (5) years of experience and approved by manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping. Any insulation subjected to moisture shall not be used.

C. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements. Maintain temperature during and after installation for minimum period of 24 hours.
PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Requirements for all products of this section:
1. Surface Burning Characteristics:
   a. Indoor insulation: Flame spread/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E 84, NFPA 255, or UL 723.
   b. Outdoor insulation: Flame spread/Smoke developed index of 75/150, maximum, when tested in accordance with ASTM E 84, NFPA 255, or UL 723.
2. Products shall not contain PVC, asbestos, lead, mercury, or mercury compounds.
3. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
4. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
5. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

B. Glass fiber, flexible:
1. Manufacturer:
   a. Knauf Insulation.
   c. Owens Corning Corporation.
   d. CertainTeed Corporation.
2. Insulation: ASTM C553; flexible, noncombustible blanket with a thermosetting resin.
   a. Density / Thermal Conductivity ('K' value):
      1) 0.75 pcf / K = 0.36 at 75 degrees F, when tested in accordance with ASTM C518.
      2) 1.5 pcf / K = 0.31 at 75 degrees F, when tested in accordance with ASTM C518.
   c. Maximum Water Vapor Sorption: 5.0 percent by weight.

C. Glass fiber, rigid:
1. Manufacturer:
   a. Knauf Insulation.
   c. Owens Corning Corp.
   d. CertainTeed Corporation.
2. Insulation: ASTM C612; rigid, noncombustible board.
   a. Density / Thermal Conductivity ('K' value):
      1) 1.6 pcf / K = 0.24 at 75 degrees F, when tested in accordance with ASTM C518.
      2) 6.0 pcf / K = 0.22 at 75 degrees F, when tested in accordance with ASTM C518.
   b. Maximum service temperature: 450 degrees F.
c. Maximum Water Vapor Sorption: 5.0 percent.

2.2 FIRE-RATED INSULATION

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a fire rating by an NRTL acceptable to authorities having jurisdiction.

B. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C 656, Type II, Grade 6. Tested and certified to provide a fire rating by an NRTL acceptable to authorities having jurisdiction.

C. Fire Rating: to suit architectural assembly, refer to Architectural Drawings.

2.3 JACKETS

A. All Service Jacket (ASJ): ASTM C1136.
   1. Vapor retarder laminate of reinforced bleached white kraft / foil.
   2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.

   1. Vapor retarder laminate of foil / scrim / kraft construction.
   2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.

   1. Thickness: 0.016 inch sheet.
   2. Finish: Stucco embossed.
   4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.

D. Aluminum Outdoor Jacket (Alum Outdoor).
   2. UV-resistant.

E. Accessories:
   2. Weld-Attached Anchor Pins and Washers: Copper-coated steel pin for capacitor discharge welding and galvanized speed washer. Pin length sufficient for insulation thickness indicated.
   3. Adhesive-Attached Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that ducts have been pressure tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NAIMA National Insulation Standards.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

E. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

F. Apply insulation with the least number of joints practical.

G. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Where service access is required, provide removable insulation sections that allow for removal and replacement without damaging surrounding insulation. At nameplates, bevel and seal ends of insulation.

H. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

I. Hangar Inserts.

1. For support points of rectangular or oval ducts supported by trapeze hangers, place weight supporting insulation at bottom of duct over trapeze. Weight supporting insulation shall be rigid glass fiber insulation having minimum of 6 pcf density and 200 lb/ft compression strength at 10% deformation and minimum 6" long with same thickness as insulation specified. Weight supporting inserts similar to HAMFAB H-block by ICA Inc. may be used for rectangular ducts less than 18". Follow manufacturer's recommendation for number of inserts.

2. For support points of round ducts smaller than 16" diameter, weight supporting insulation is not required for either rigid or flexible glass fiber insulation.

3. For support points of round ducts 16" diameter and larger, place weight supporting insulation between duct and strap or trapeze.

4. Flexible glass fiber insulation may be installed outside of support for round ducts 24" diameter or smaller, provided vapor barrier integrity is maintained at rod / strap penetration.
J. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

K. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.

L. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

M. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.

N. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.

O. External Duct Insulation Application:
   1. Secure insulation with vapor barrier and seal jacket joints with vapor barrier adhesive or tape to match jacket.
   2. Secure insulation without vapor barrier with staples or tape.
   3. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
   4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
   5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

3.3 SCHEDULES

A. Items Not Insulated:
   1. Double-wall metal ducts which comply with energy code and ASHRAE/IESNA 90.1.
   2. Factory-insulated flexible ducts.
   3. Factory-insulated plenums and casings.
   4. Flexible connectors.
   5. Vibration-control devices.
   6. Factory-insulated access panels and doors.
   7. Transfer air ducts.

B. Location definitions:
   1. Concealed: ductwork in ceilings and shafts.
   2. Exposed: ductwork that is not concealed, but also not in occupied spaces such as ductwork in mechanical rooms.
   3. Occupied: ductwork in occupied rooms.

<table>
<thead>
<tr>
<th>Type</th>
<th>Location</th>
<th>Insulation</th>
<th>Minimum Thickness</th>
<th>Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply / Outside Air</td>
<td>Outdoor</td>
<td>Fiber Board 6.0 pcf or Fiber Wrap 1.5 pcf</td>
<td>2.0 inch</td>
<td>Alum Outdoor</td>
</tr>
<tr>
<td></td>
<td>Concealed</td>
<td>Fiber Board 1.6 pcf or Fiber Wrap 0.75 pcf</td>
<td>1.5 inch</td>
<td>FSK</td>
</tr>
<tr>
<td></td>
<td>Exposed up to 8’ AFF</td>
<td></td>
<td>1.5 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF</td>
<td></td>
<td>1.5 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Return / Exhaust upstream of heat recovery</td>
<td>Occupied</td>
<td>1.5 inch</td>
<td>Alum</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>-------------------</td>
<td>----------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Outdoor</td>
<td>Fiber Board 6.0 pcf or Fiber Wrap 1.5 pcf</td>
<td>2.0 inch</td>
<td>Alum Outdoor</td>
<td></td>
</tr>
<tr>
<td>Concealed</td>
<td>Fiber Board 1.6 pcf or Fiber Wrap 0.75 pcf</td>
<td>1.5 inch</td>
<td>FSK</td>
<td></td>
</tr>
<tr>
<td>Exposed up to 8’ AFF</td>
<td>1.5 inch</td>
<td>Alum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposed above 8’ AFF</td>
<td>1.5 inch</td>
<td>ASJ</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 230700 – HVAC PIPING AND EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Pipe and equipment insulation.
   2. Pipe and Equipment jackets.

B. Related Sections:
   1. Division 01 – Volatile Organic Compound (VOC) Content Restrictions.
   2. Division 07 – Firestopping.
   3. Division 09 – Painting and Coating: Painting insulation jackets.
   4. Section 230553 – Identification for HVAC Piping and Equipment.
   5. Section 232113 – Hydronic Piping.

1.3 REFERENCE STANDARDS


1.4 ACTION SUBMITTALS

A. See Division 01 and Section 230000 “HVAC General Requirements” for submittal procedures.

B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

C. Manufacturer’s Instructions: Indicate installation procedures which ensure acceptable workmanship and installation standards will be achieved. Include details for removable insulation sections at access panels.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.

B. Applicator Qualifications: Company specializing in performing the type of work specified in this section, with minimum five (5) years of experience and approved by manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labelled with manufacturer’s identification, including product density and thickness.

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping. Any insulation subjected to moisture shall not be used.

C. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 - PRODUCTS

2.1 PIPE AND EQUIPMENT INSULATION

A. Requirements for all products of this section:

1. Surface Burning Characteristics:
   a. Indoor insulation: Flame spread/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, NFPA 255, or UL 723.
   b. Outdoor insulation: Flame spread/Smoke developed index of 75/150, maximum, when tested in accordance with ASTM E84, NFPA 255, or UL 723.

2. Products shall not contain PVC, asbestos, lead, mercury, or mercury compounds.
3. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

B. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials.
   1. Manufacturers:
      a. Aeroflex USA.
      b. Armacell LLC.
      c. K-Flex USA LLC.
      d. Armstrong World Industries.

C. Mineral Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type II. Maximum moisture absorption: 0.2 percent by volume.
   1. Manufacturers:
      a. Knauf Insulation.
      c. Owens Corning Corporation.
   2. CertainTeed Corporation.

D. Mineral Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less.
   1. Manufacturers:
      a. Knauf Insulation.
      c. Owens Corning Corporation.
   2. CertainTeed Corporation.

2.2 PIPE AND EQUIPMENT JACKETS

A. Aluminum Jacket: ASTM B209 formed aluminum sheet. Thickness 0.016 inch; smooth finish, longitudinal slip joints and 2 inch laps, 0.016 inch thick die shaped fitting covers with factory-attached protective liner; stainless steel bands.
   1. Moisture Barrier for Indoor Applications: 1 mil- thick, heat-bonded polyethylene and kraft paper.
   2. Moisture Barrier for Outdoor Applications: 3 mil- thick, heat-bonded polyethylene and kraft paper.
   3. Factory-Fabricated Fitting Covers:
      a. Same material, finish, and thickness as jacket.
      b. Preformed 2 piece or gore, 45 and 90 degree, short- and long-radius elbows.
      c. Tee covers.
      d. Flange and union covers.
      e. End caps.
      f. Beveled collars.
      g. Valve covers.
      h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
B. All Service Jacket (ASJ): ASTM C291, laminated glass-fiber-reinforced, flame retardant kraft paper and aluminum foil. Moisture permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that ducts have been pressure tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.2 PIPE AND EQUIPMENT INSULATION INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Install in accordance with NAIMA National Insulation Standards.

C. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

D. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

E. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

F. Apply insulation with the least number of joints practical.

G. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

H. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

I. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

J. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

K. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.

L. Exposed Piping and equipment: Locate insulation and cover seams in least visible locations.
M. Insulated pipes: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints with molded insulation of like material and thickness as adjacent pipe.

N. For hot piping, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

O. Inserts and Shields:
   1. Application: Piping 1-1/2 inches diameter or larger.
   2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
   3. Insert location: Between support shield and piping and under the finish jacket.
   4. Insert configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
   5. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

P. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Division 07.

Q. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.

R. Finish insulation at supports, protrusions, and interruptions.

S. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.

3.3 FIELD QUALITY CONTROL

A. Inspect work, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall include all equipment and be limited to one location for each duct or pipe system.

B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.4 SCHEDULES

A. Pipe Items Not Insulated:
   1. Drainage piping located in crawl spaces.
   2. Chrome-plated piping and fittings.

B. Location definitions:
   1. Concealed: located in ceilings and shafts.
   2. Exposed: not concealed, but also not in occupied spaces such as in mechanical rooms.
   3. Occupied: located in occupied rooms.
<table>
<thead>
<tr>
<th>Type</th>
<th>Location</th>
<th>Insulation</th>
<th>Minimum Thickness</th>
<th>Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Hot Water Equipment, Chilled Water Pumps</td>
<td>Exposed up to 8’ AFF</td>
<td>Mineral Fiber Board</td>
<td>2.0 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF, Concealed</td>
<td>Mineral Fiber Board</td>
<td>2.0 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Chilled Water Air Separators and Expansion Tanks</td>
<td>Exposed up to 8’ AFF</td>
<td>Mineral Fiber Board</td>
<td>1.5 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF, Concealed</td>
<td>Mineral Fiber Board</td>
<td>1.5 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Heating Hot Water Piping, NPS 1” and larger</td>
<td>Exposed up to 8’ AFF</td>
<td>Mineral Fiber</td>
<td>1.5 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF, Concealed</td>
<td>Mineral Fiber</td>
<td>1.5 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Heating Hot Water Piping, NPS 3/4” and smaller</td>
<td>Exposed up to 8’ AFF</td>
<td>Mineral Fiber</td>
<td>1.0 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF, Concealed</td>
<td>Mineral Fiber</td>
<td>1.0 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Chilled Water Piping, NPS 1-1/2” and larger</td>
<td>Exposed up to 8’ AFF</td>
<td>Mineral Fiber</td>
<td>1.0 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF, Concealed</td>
<td>Mineral Fiber</td>
<td>1.0 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Chilled Water Piping, NPS 1-1/4” and smaller</td>
<td>Exposed up to 8’ AFF</td>
<td>Mineral Fiber</td>
<td>0.5 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF, Concealed</td>
<td>Mineral Fiber</td>
<td>0.5 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Refrigerant Piping</td>
<td>Any</td>
<td>Elastomeric</td>
<td>1.0 inch</td>
<td>None</td>
</tr>
</tbody>
</table>

Note 1: minimum thickness may be adjusted for alternate insulating materials, but must still meet all applicable codes.

Note 2: all outdoor piping and equipment shall be provided with an aluminum jacket rated for outdoor use.

END OF SECTION
SECTION 230800 – COMMISSIONING OF MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1. RELATED DOCUMENTS

A. The General Conditions, Supplementary Conditions and Division 01 are fully applicable to this Section, as if repeated herein.

1.2. RELATED WORK SPECIFIED ELSEWHERE

A. Division 01, Section 01910, General Commissioning Requirements

B. All Division 23 Sections.

1.3. REFERENCES

A. USGBC:
   1. LEED v4.0 Reference Guide for Building Design and Construction:
      a. Energy and Atmosphere Prerequisite: Fundamental Commissioning and Verification.

B. California Energy Commission:
   1. Title 24, Part 6, 2016, Building Energy Efficiency Standards, Section 10-103 and Section 120.8-Building Commissioning

C. ASHRAE:
   1. ASHRAE Guideline 0-2013: The Commissioning Process
   2. ASHRAE Guideline 1.1-2007 HVAC&R Technical Requirements for the Commissioning Process

1.4. DEFINITIONS

A. Basis of Design (BOD): The documentation of design criteria and assumptions for systems, components, and methods chosen to meet the Owner’s Project Requirements and applicable regulatory requirements, standards, and guidelines. The document includes narrative descriptions of the systems to be commissioned. The BOD is prepared by the Design Professionals.

B. Building Automation System (BAS): The automated building system providing control and user interaction with select building systems, such as the HVAC, domestic hot water and lighting systems. Also, often referred to as building management system (BMS), energy management system (EMS), or an energy management and control system (EMCS).

C. Commissioning (Cx): A quality-focused process to verify and document that building systems are installed and perform as intended per the OPR, BOD and design documents.
D. Commissioning Authority (CxA): An independent agent hired directly by the Owner and not otherwise associated with the Design Professionals or the General Contractor. The CxA is the authority on commissioning results and other commissioning program elements completion, and assists the General Contractor with coordinating commissioning activities and witnesses the activities on behalf of the Owner.

E. Commissioning Issue: A condition that affects, prevents or inhibits commissioning, and must be resolved to complete the commissioning process.

F. Commissioning Issues & Recommendations Log (Cx Log): A log maintained by the CxA listing and describing all Cx issues and recommendations documented during the commissioning process, including providing the status, recommended action, contractor updates and resolution, and associated dates. All Cx issues require action, correction and closure.

G. Commissioning Report (Cx Report): The final report issued at the conclusion of the commissioning process. The report will include an executive summary abbreviating the outcome of the commissioning process and identifying all outstanding issues. The report also contains all commissioning documentation collected throughout all phases of the project.

H. Commissioning Plan (Cx Plan): A document that outlines the organization, coordination, and requirements of the commissioning process in more detail and contains project specific commissioning forms.

I. General Contractor (GC): The contractor directly contracted to the Owner with overall responsibility for the project and all commissioning activities described herein.

J. Commissioning Coordinator (CxC): Individual within the GC firm who plans, schedules, directs and coordinates all the Trade Subcontractor’s commissioning activities, and serves as the CxA’s single point of contact for all administrative, documentation and coordination functions.

K. Deferred Testing: Testing performed at a later time, due to partial occupancy, equipment, load, seasonal requirements, design or other site conditions that disallow the test from being performed prior to substantial completion.

L. Deficiency: A condition in the installation, function or performance of a component, equipment or system that is not in compliance with the contract documents and design. A deficiency will be considered a Cx issue and documented on the Cx Log.

M. Design Professional (DP): Architects, engineers and other consultants involved in the design of the project.

N. Functional Performance Test (FPT): A test of the dynamic function, operation and control of the equipment and systems to verify system performance to the fullest extent. Systems are tested under various operating modes and control sequences including failure modes. The FPTs are performed using manual (direct observation) or monitoring methods. The FPTs can include sequence of operation tests, performance tests, verification tests, integrated systems tests, and trend analysis.

O. HVAC&R: Heating, ventilation, air conditioning and refrigeration.

P. Installation Verification (IV): Field verification and documentation of proper installation of system equipment, assemblies and components, per design documents and manufacturer requirements. The IV process is typically complete when systems are ready for startup or operation. IV is organized and documented under the System Readiness Checklist (SRC) forms.
Q. Monitoring: The recording of parameters (temperature, flow, current, status, pressure, etc.) of equipment operation, which shall be completed using data-loggers or the trending capabilities of BAS or control systems.

R. Owner’s Project Requirements (OPR): A document describing the operational and functional requirements of a project, the expectations of how the facility will be used and operated, and the equipment and system expectations and requirements, as defined by the Owner. This document provides an explanation of the ideas, concepts, goals, success criteria, and supporting information for the project.

S. Percent Sampling: Witnessing the startup, checkout or testing of a selected fraction of the total number of identical or near-identical pieces of equipment or systems.

T. Pre-Functional Checks and Tests (PFCT): These are various checks and tests performed on a piece of equipment or system before, during, or after the initial startup and operation, but prior to the FPT phase. They are performed to confirm the system equipment and individual components were installed correctly and are working properly and meeting applicable performance requirements and specifications. For mechanical HVAC systems, examples during the system installation prior to equipment startup include: pipe system hydrostatic pressure tests, checking completion of the pipe system clean and flush, and duct leakage tests. Examples during equipment startup and operation include: checking fan rotation and measuring and checking operating temperatures, pressures and motor electrical parameters. Examples after equipment startup include: the BAS / control system point to point checks, sensor calibrations or accuracy checks, actuator testing; and system TAB. They are all organized and documented under the SRC forms and are to be completed prior to FPTs.

U. Startup: Initial starting or activating of equipment usually performed by the Trade Subcontractor or the Manufacturer’s authorized representative.

V. Systems Manual: A manual that provides the operating staff the information needed to understand and optimally operate the commissioned systems. It expands upon the scope of traditional operating and maintenance documents and is compiled of multiple documents such as the final BOD, single line diagrams, and as-built controls drawings and sequences of operation.

W. System Readiness Checklist (SRC): A construction checklist, typically one or two pages, listing the necessary commissioning tasks and required documentation to verify a system is ready for FPTs, or system operation if no FPTs are performed. The tasks covered in the SRC include IV, Startup and PFCT, and the Trade Subcontractor completed forms for these tasks are attached to the specific SRC. The SRC must be completed and signed by the GC prior to conducting the FPTs.

X. TAB: Testing, Adjusting, and Balancing (TAB) work on the HVAC&R air and water systems to ensure design flow, pressure and temperature conditions are met. Performed by the TAB Trade Subcontractor.

Y. Trade Subcontractor: Typically a subcontractor to the GC who provides and installs specific building components and systems and/or provides certain services.

Z. Trending: Monitoring using the BAS or a control system, to aid in functional testing and to verify system operation and performance under actual operating conditions.

AA. Warranty Phase: The phase of the project immediately after the initiation of the building equipment warranty which spans the entire length of the project warranty.
1.5. DESCRIPTION OF WORK

A. Systems and equipment to be commissioned:
   1. HVAC equipment, controls and the BAS

B. Process equipment are not included in the commissioning scope of work.

C. The work includes the completion and documentation of formal commissioning procedures by the GC and Trade Subcontractors.
   1. The GC and Trade Subcontractors shall provide the quality control for the installation, startup, checkout and testing of the systems. The commissioning process provides independent review throughout the process and qualitative functional performance testing in order to formally observe and document the quality control efforts are completed.
   2. Refer to Section 01910, General Commissioning Requirements for summary description of the general commissioning process and requirements.
   3. The Trade Subcontractors and the factory authorized service representatives shall be responsible for participation in the commissioning process as outlined in this specification and Section 01910, General Commissioning Requirements.

1.6. COMMISSIONING PROCESS

A. Submittal Reviews by the CxA
   1. The CxA will review pertinent Trade Subcontractor submittals for the appropriate systems in the commissioning scope, concurrently with the Design Professionals and will provide review comments to the Design Professionals.
   2. The GC shall provide a submittal log to the CxA for referencing the requested submittals to be reviewed by the CxA (for which the GC shall issue to the CxA concurrently with the submission to the Design Professionals). Alternatively, the GC shall include the CxA on the distribution of all Trade Subcontractor submittals issued to the Design Professionals, for systems applicable to this specification.
   3. The GC shall issue the requested submittals to the CxA for review at the same time they issue the submittals to the Design Professionals.
   4. The CxA will also use the information from the submittals to develop commissioning forms and test procedures.

B. Cx Plan and Form Development
   1. The CxA prepares a Preliminary Cx Plan either during the project final design phase or early construction phase. The Cx Plan provides guidance in the execution of the commissioning process during construction and will contain the project specific commissioning forms.
   2. Commissioning during construction begins with a kickoff meeting conducted by the CxA where the CxA reviews the commissioning process and responsibilities with the appropriate team members. The CxA presents the Preliminary Cx Plan and discusses the project specific requirements.
   3. The CxA develops the SRC forms, which list the commissioning tasks and the associated IV, Startup, and PFCT documentation required for each system and equipment to be commissioned.
   4. The CxA provides the SRC forms to the GC and Trade Subcontractors for review and comment.
   5. The CxC shall submit to the CxA, for review and approval, the representative blank IV, Startup, and PFCT forms and plans for completing all IV, Startup, and PFCT tasks, prior to conducting any of these tasks.
Contra Costa Community College District
Contra Costa College
C-4016 New Science Building – DSA Increment 2

C. System Readiness (Pre-Functional) Activities

1. Meetings will be conducted throughout construction with commissioning team members, as required, to plan, coordinate, and schedule commissioning activities, review documentation, and resolve Cx issues.

2. The Trade Subcontractors shall perform the IV, Startup and PFCT tasks for all systems and equipment (no sampling allowed), unless the contract or design documents allow for sampling of the pre-functional tests (as example, if sampling were allowed for pre-functional HVAC system duct leakage tests).

a. In general, the GC and Trade Subcontractors should complete IV prior to Startup, but where appropriate and approved by the CxA, they can combine IV and Startup into one activity (and Startup is not performed if there are deficiencies identified from the IV).

3. The Trade Subcontractors and the CxC shall document completion of the IV, Startup and PFCT tasks on the IV, Startup, PFCT and SRC forms, and shall complete the SRC forms and attach the completed IV, Startup, and PFCT forms to the SRCs forms.
a. The intent of the SRC forms is for the GC and Trade Subcontractors to certify that the HVAC systems, controls and instrumentation, equipment and assemblies have been installed, started, calibrated and are operating per the contract and design documents.

4. The CxA will review the completed IV, Startup, PFCT and SRC forms. The CxA will also perform various field observations and reviews, and witness a sample of the Startup and PFCT activities (some PFCT witnessing may be performed as back-checks after PFCT task are completed, e.g., BAS pre-functional checks and TAB).

a. The Trade Subcontractor shall resolve any IV and PFCT results deemed unacceptable by the CxA. And the Trade Subcontractor shall execute a new sample of the PFCT to be witnessed by the CxA. The CxA shall deem the PFCT acceptable after resolution of all issues and any witnessed sampling results in no issues.

5. The CxC shall submit all completed SRC forms to the CxA for review prior to conducting the FPTs. The CxA shall deem the SRCs acceptable after all SRC forms and supporting IV, Startup and PFCT forms are complete and any issues have been addressed.

D. Functional Performance Testing

1. FPTs are to test the dynamic function, performance and control of the equipment and systems under various modes of operation. These tests verify the correct implementation of the sequences of operation and the system performance meets the design criteria. The FPTs are performed using manual (direct observation) or monitoring methods. FPTs include the following types of tests, where applicable:

a. Sequence of Operation Tests
   1) Sequence of operation tests are witnessed by the CxA for each unique sequence of operation but may not necessarily be repeated across identical systems, equipment or spaces, if the contractor has verified the same programmed sequence of operation code (as tested) has been programmed across multiple identical systems, equipment or spaces, based sample verification tests witnessed by the CxA (see below).

b. Verification Tests.
   1) Verification tests are often less detailed tests than the sequence of operation tests and are typically witnessed by the CxA at a higher sample rate. Examples of verification tests include:
      a) verifying the programmed sequence of operation code is the same as the as-tested code per the sequence of operation tests,
      b) verifying the alarm points are configured per the sequence of operation tests (without having to repeat the actual sequence tests),
      c) reviewing and confirming control point displays on system graphics and required setpoints (for example verifying the BAS VAV min, max cool, max heat airflow setpoints are correct per design),
      d) testing certain critical or important sequences with a higher sample rate across identical systems, equipment or spaces, beyond the individual sequence of operation tests.

c. Performance Tests.
   1) Performance tests are to be performed after the sequence of operation and verifications tests, and are focused on testing and verifying performance (i.e., HVAC system air and water flow rates, temperatures, pressures are achieved at both minimum and near maximum load conditions). Performance tests are typically witnessed by the CxA at a lower sample rate. Examples include:
a) testing VAV terminal unit maximum airflow rates and reheat coil airside
temperature rise are achieved per design (at design air handler static
pressure and hot water temperature and differential pressure),
b) testing AHU minimum outside air ventilation rates per design are
achieved at both minimum and maximum supply airflows,
c) testing the AHU supply airflow and temperature performance at
simulated high cooling load conditions per design.
d) Testing the chilled water system flow and cooling capacity performance
at simulated high cooling load conditions per design.

d. Integrated Systems Tests.

1) Integrated systems tests verify the operation and performance of multiple
systems together operating in a coordinated, stable and efficient manner. Often
the integrated systems tests are combined with the performance tests.
Examples include verifying the operation and performance of the central
heating and chilled water systems with the performance of terminal and/or air
handling units, from simulated minimum to near maximum load conditions,
including staging up and down of central equipment (chiller, boilers, pumps,
etc.).

e. Trend Analysis

2. The CxA will develop FPT forms that contain:

a. Specific step-by-step procedures to execute the test in a clear, sequential and
repeatable format, including any control system point value or setpoint overrides
required to simulate a test condition or sequence mode.
b. The expected system response and acceptance criteria of proper performance with a
Yes/No check box to allow for clearly marking whether or not proper performance of
each part of the test was achieved.
c. A section for recording actual system response, notes and comments.

3. Once the SRC forms are complete, the Trade Subcontractors shall execute the FPTs, with
the FPTs witnessed by the CxA.

a. The GC and Trade Subcontractors are responsible for ensuring all systems are
installed, operating and performing per the requirements of the contract and design
documents, and are ready for the FPTs.
b. The Trade Subcontractors shall determine what level of pre-testing is appropriate in
order to prepare for the CxA witnessed FPTs.
c. The CxA recommends the Trade Sub-Contractors complete the Title 24 acceptance
testing and forms (see paragraph f below) as part of the contractor’s pre-testing and
readiness for the CxA witnessed FPTs.
d. A percent sampling approach shall be used for executing the FPTs of identical
systems and equipment. The approximate system sampling rates for the manual
(direct observation) FPTs are defined in Part 3 of this specification and/or in the Cx
Plan.
e. The acceptance criteria for the FPT sampling shall be zero, meaning, any FPTs that
do not pass shall require the Trade Subcontractor to resolve the issue for all
applicable systems and equipment (even those specifically not in the original sample)
and new sample rates selected for a re-test executed by the Trade Subcontractor
and witnessed by the CxA. The CxA shall deem the FPTs acceptable after all FPTs,
including re-tests, have passed and resolution of all issues completed.
f. The CxA will document the results of all FPTs on the associated FPT forms created
by the CxA, unless indicated otherwise on the FPTs, and excluding completion of the
Title 24 Certificate of Acceptance forms.
1) Completion of the Title 24 Certificate of Acceptance forms (contained in Appendix A of the Title 24, Part 6 Compliance Manual) is a contractor responsibility, not the CxA responsibility.

2) The responsible Division 22, 23, 25 and 26 Trade Subcontractors are also responsible for providing qualified and certified "Field Technicians" (per Title 24, Part 6 requirements, where applicable when the minimum threshold of state certified technicians has been met) to perform and document the results of the acceptance tests on the applicable Title 24, Part 6 Certificate of Acceptance forms.

4. The Cx Plan will define any required seasonal or deferred testing.

E. Cx Issues and Recommendations

1. Throughout the process, the CxA records Cx issues and recommendations on the Cx Log and distributes the Cx List to the team. The GC and Trade Subcontractors shall correct Cx issues and recheck or retest the system(s) without delay at no additional cost to the Owner. The CxA will verify the completion of the issues and recommendations, and make all amendments to the Cx Log.

F. Training Verification and Final Documentation

1. The GC shall submit a comprehensive Training Plan (with specific training agendas provided by the Trade Subcontractors) for review by the Design Professionals, CxA and Owner, prior to conducting any training. The Training Plan shall meet the specific requirements in the contract documents and specifications for each applicable system to be commissioned and the LEED Enhanced Commissioning requirements, and may include both operations and maintenance (O&M) staff training and building occupant training. The GC shall coordinate with the Owner and/or Owner’s Representatives, as needed, regarding any specific requirements for occupant training.

2. The CxA will verify completion of the training by witnessing some training sessions and receiving a copy of all training class sign-in sheets and any training materials / handouts, to be provided by the CxC or Trade Subcontractors.

3. The CxA will develop the Systems Manual (per the LEED requirements), including the current facility requirements, preventative maintenance information and an ongoing Cx plan, with assistance from the GC and Trade Subcontractors.

4. The CxA will complete the Commissioning Report and all associated documentation for the Owner with assistance from the GC and Trade Subcontractors.

G. Post-Occupancy Warranty Phase Commissioning

1. The CxA will report any identified operational or performance issues (identified by the building O&M staff or warranty phase Cx activities) to the CxC via a Warranty Phase Cx Log for resolution by the GC and Trade Subcontractors during or prior to the end of the warranty period.

2. The Trade Subcontractors shall execute any defined seasonal or deferred FPTs, witnessed by the CxA.

3. The CxA may review and analyze trend data during the Warranty Phase and will report any identified issues and recommendations for system improvements from the trend analysis.

4. No later than either 10 months after substation completion or two months prior to the expiration of the first 12-month warranty period of building occupancy, the CxA will return to the facility to interview facility O&M staff, walk the facility and review systems operation and trend data where applicable. Key representatives from the GC and Trade Subcontractors shall attend a site walk-through and meeting, as determined by the CxA.

1.7. COMMISSIONING TEAM
A. The Commissioning Team is responsible for performing the process and achieving successful commissioning results. The Commissioning Team is comprised of the following:

1. Owner and Owner’s Representatives
2. Commissioning Authority (CxA).
3. Design Professionals
4. General Contractor (GC)
5. GC’s Commissioning Coordinator (CxC)
6. Trade Subcontractors responsible for systems covered in this section include:
   a. Mechanical Contractor
   b. BAS / HVAC Controls Contractor
   c. TAB Contractor
7. Manufacturer Representatives supplying equipment, materials, components and controls for the systems to be commissioned.

1.8. RESPONSIBILITIES

A. General.
   1. The Commissioning Team and all others involved in the commissioning process shall follow the Commissioning Plan, attend the commissioning kickoff meeting, and attend additional commissioning meetings as necessary.

B. Commissioning Authority (CxA)
   1. See Section 01910, General Commissioning Requirements.

C. General Contractor:
   1. See Section 01910, General Commissioning Requirements.

D. Trade Subcontractors – General Requirements:
   1. Provide and submit for CxA review, the representative blank forms and plans for completing all IV, Startup, and PFCT tasks, including manufacturer’s installation checks and startup procedures. Electronic files are acceptable.
   2. Provide any equipment and construction submittals and shop drawings, including detailed sequences of operation, and any other requested contract documentation for systems to be commissioned, as requested by the CxA. Electronic files are acceptable.
   3. Attend commissioning meetings as directed by the CxA and GC’s CxC to facilitate the commissioning process.
   4. Assign personnel with expertise and authority to act on behalf of the Trade Subcontractor and schedule them to participate in and perform assigned commissioning tasks.
   5. Ensure that any required manufacturer factory tests are performed and provide the factory test data and results where required.
      a. Perform IV, Startup and PFCT tasks for all systems and equipment (no sampling), unless the contract or design documents allow for sampling of these tasks.
      b. Complete all IV, Startup and PFCT documentation clearly and legibly.
      c. Submit all completed IV, Startup and PFCT forms to the CxC and CxA, as part of completing the SRC forms, for review by the CxA.
   7. Provide a schedule and access for the CxA to witness any equipment Startup and PFCT tasks. Notify the CxC and CxA at least 10 days in advance of Startup and PFCT tasks.
   8. Ensure that any required manufacturer’s representative field tests and on-site IV, startup and checkout of selected equipment are performed per the contract documents. Provide
completed manufacturer documentation and commissioning forms for these activities to the CxC.

9. Address applicable Cx issues promptly. All IV, Startup and PFCT issues must be resolved before the FPTs can proceed.

10. Assist the CxA in preparing the FPT procedures, clarifying the operation and control of commissioned equipment where the specifications, control drawings or equipment documentation are not sufficient for writing detailed testing procedures.

11. Review the FPT procedures to ensure feasibility, safety and equipment protection, and provide necessary written alarm limits, setpoint changes and overrides to be used during the tests.

12. Setup any additional control system software points, global commands, overrides of any sensor values or relays, and overrides of any setpoints or schedules, to simulate certain conditions and operating modes, in order to conduct the FPTs.

13. Perform the FPTs, with the FPTs witnessed by the CxA. Provide at least 10 days advance notice to the CxC and CxA for scheduling the FPTs.

14. The Division 23 and 25 Trade Subcontractors (Mechanical, TAB and BAS) are responsible for providing qualified and certified "Field Technicians" (per Title 24, Part 6 requirements, where applicable) to perform and document the results of the acceptance procedures (Acceptance Tests) on Certificate of Acceptance forms per Title 24, Part 6.

   a. The GC or the responsible Trade Subcontractor shall be the designated "Responsible Person" per Title 24, Part 6, for certification of the acceptance testing/verification on the Certificate of Acceptance forms (contained in Appendix A of the Title 24, Part 6 Compliance Manual).

15. Setup the BAS and any other control system trends and provide all requested Trend data for the FPTs and post-occupancy warranty phase commissioning review to the CxA.

   a. As an Owner approved alternative, the Trade Subcontractors may provide the CxA remote access to the BAS and any other control system, with the Owner's permission, which will allow the CxA to easily and directly download the trend data files.

16. Prepare a training agenda for each training class for the equipment and systems to be commissioned.

17. Coordinate with the GC and Owner to schedule and plan training. Execute training of Owner’s personnel per approved training agenda and schedule. Provide copies of training class sign-in sheets and materials / handouts.

18. Prepare O&M Manuals according to the Contract Documents.

19. Assist the CxA in developing the Systems Manual, including providing as-built drawings, controls sequences, setpoints, single-line diagrams, etc., necessary for the Systems Manual.

E. Trade Subcontractors – Specific Mechanical System Requirements

1. In addition to the general Trade Subcontractor responsibilities outlined above, the Mechanical Trade Subcontractor responsibilities during commissioning shall include, but are not limited to:

   a. Provide approved submittals, including shop drawings, control drawings, points list and detailed sequences of operation for each piece of equipment and system to be controlled (including any local, stand-alone controls independent of the BAS controls). The system sequence of operation shall fully describe their equipment components and functionality, including setpoints, failure modes and alarm functions. The detailed sequence of operation shall be provided regardless of the completeness and clarity of the sequences in the controls specification and/or drawings. Electronic files are acceptable.
b. Provide a list of any test metering and sensors to be used for sensor and device calibration purposes. All test meter and sensors shall have been calibrated within a year and have calibration documentation.

c. Submit the Duct Leakage Test Plan(s), for review by the CxA, at least 4 weeks in advance of conducting any required duct leakage pre-functional tests. The Plan shall include the following items:

   1) Floor plan drawings showing the duct section(s) to be tested.
   2) The total duct square footage for each duct section to be tested. Provide supporting calculations showing how the square footage was calculated for each duct section.
   3) The SMACNA duct leakage class for each duct section to be tested, per the project specifications or the SMACNA Duct Leakage Test Manual if not defined in the specifications.
   4) The intended test static pressure for each duct section.
   5) The calculated allowable leakage rate (cfm) for each duct section to be tested, based on the allowable leakage rate (per 100 square feet) from the SMACNA Duct Leakage Test Manual Figure 4-1 at the intended test pressure.
   6) Test fan orifice certificate of calibration sheet and chart showing the orifice pressure drop and airflow (cfm).

d. Submit any applicable Underfloor Air Distribution (UFAD) Leakage Test Plan(s), for review by the CxA, at least 4 weeks in advance of conducting any required UFAD leakage pre-functional tests. The Plan shall include the following items:

   1) Floor plan drawings showing the UFAD plenum(s) to be tested.
   2) For each UFAD plenum to be tested, provide the following:
      a) The plenum dimensions and calculated area (square footage).
      b) The acceptable maximum leakage criteria (cfm per square foot) for any required Category 1, Category 2 and Total Category 1 + 2 leakage, per the project specifications, and the associated absolute leakage rates (cfm) for each plenum. If the project specifications do not define the leakage criteria, the CxA shall define the leakage criteria with the Owner's approval.
   3) The specific tests procedures for each type of test (Category 1 or Total Category 1 + 2), including any associated temporary test taping or sealing to be performed prior to the tests, the plenum test static pressure, the plenum pressure measurement locations and manometers to be used, and any diagnostic procedures (such as smoke testing) to be performed upon tests not passing.
   4) Test fan orifice certificate of calibration sheet and chart showing the orifice pressure drop and airflow (cfm).

e. Submit a Hydronic Pipe System Pressure / Leak Test Plan for all applicable hydronic systems, for review by the CxA, at least 4 weeks in advance of conducting any required tests. The Test Plan shall include the section of pipe to be tested, and the test methods, pressures and durations.

f. Submit a Refrigeration Pipe Test Plans for all applicable refrigeration systems, for review by the CxA, at least 4 weeks in advance of conducting any required tests. The Plan shall include the refrigeration piping to be tested, methods and procedures, equipment and gases to be used, pressures and durations.

g. Submit a Clean, Flush and Treatment Plan for all applicable hydronic systems, for review by the CxA, at least 4 weeks in advance of filling any hydronic systems. The Plan shall include the following:

   1) The intended minimum durations for all pipe cleaning and flushing, and the associated cleaning agents and corrosion inhibitors to be used.
2) An outline of the water chemical treatment, analysis and testing to be performed after cleaning and flushing is complete. At a minimum, the following shall be included:

a) the proposed chemicals, corrosion inhibitors and biocides, to be added as part of the water treatment,

b) outlining the water chemistry analysis and corrosion testing to be conducted,

c) and the intended final water chemistry limits or ranges (including steel, iron and copper levels) to be achieved, in order to meet the specifications and any specific manufacturer requirements.

3) The timing for submitting the Water Treatment Analysis Reports for review by the Design Professional and CxA.

h. Submit Plans for all other applicable mechanical systems pre-functional testing, per the project specifications, for review at least 4 weeks in advance of any required tests.

i. Participate in any applicable integrated whole building tests under emergency power. This test is initiated by disconnecting the utility power to the building, and it will involve multiple disciplines. All Trade Subcontractors shall participate in the FPTs as required for operation of the inter-related systems.

F. Trade Subcontractors – Specific BAS and HVAC Controls Requirements

1. For the BAS and HVAC&R system controls (inclusive any local equipment factory provided controls or local stand-alone controls not part of the BAS), in addition to the general Trade Subcontractor responsibilities outlined above, the Mechanical and/or BAS Trade Subcontractor responsibilities during commissioning shall include, but are not limited to:

a. Provide approved submittals, including shop drawings, control drawings, points list and detailed sequences of operation for each piece of equipment and system to be controlled. The system sequence of operation shall fully describe their equipment components and functionality, including setpoints, failure modes and alarm functions. The detailed sequence of operation shall be provided regardless of the completeness and clarity of the sequences in the controls specification and/or drawings. Electronic files are acceptable.

b. Provide a complete control points list in MS Excel or other pre-approved format (for all BAS, local equipment provided, and local stand-alone control points). Points list shall include point name, point description, display units (i.e. degrees F, percent, psi), panel identification, point type (AI, AO, BI, BO, virtual/software), field device controlled (through network, dry contact, actuator limit switch or other specific equipment), BAS application or energy management function associated with point, and associated alarm points and parameters, etc. The BAS Trade Subcontractor shall make all points available for continuous trending.

c. Provide control system diagrams showing all control points, sensor locations, actuators, and controllers.

d. Provide a list of any test metering and sensors to be used for sensor and device verification and calibration purposes. The list shall include test meter and sensor accuracy for comparison to the BAS and local control system sensor accuracy requirements specified in contract documents. All test meter and sensors shall have been calibrated within a year and have calibration documentation.

e. Submit representative blank forms for conducting all BAS and HVAC System Controls IV and PFCT tasks to be conducted by the Trade Subcontractors, for review by the CxA, at least 4 weeks in advance of performing any controls related Controls IV and PFCT tasks. For local HVAC equipment factory provided or local stand-alone HVAC controls, these forms can be included in the equipment specific IV and Startup forms (for example, as part of the mechanical contractor’s or the manufacturer
representative’s IV and Startup forms for the specific equipment inclusive of all local controls). The forms shall include:

1) Installation verification checks of the control input and output points (sensors, actuators, relays, etc.) to verify all points have been installed per the points list and the physical installation of each point has been verified.

2) Control system program setup checks, e.g., point type, range/scale, etc.

3) Point-to-point checks with the BAS operating system software graphics or local controller display interface or graphics.

4) Sensor accuracy checks or calibration results:
   a) For analog input sensors that are factory calibrated (no field calibration is required per the Specifications):
      i. The control system program setup (as noted above) shall be verified and recorded in the PFCT forms for all sensors, and all sensor readings on the BAS graphics or local controller display shall be recorded on the PFCT forms and shall be checked by verifying the BAS reading is within the expected range.
      ii. Sensor readings that are questionable or outside the expected range shall be checked by the BAS or Mechanical Trade Subcontractor using a hand-held sensor of equal accuracy.
   b) For sensors that require field calibration, follow the manufacturer requirements for calibration and record the calibration results in the PFCT forms, including any readings using a hand-held sensor of equal accuracy.

5) Actuator checks:
   a) At a minimum, all actuators shall be physically checked at commanded full open position (100% open), commanded half-open position (50% open) and commanded fully closed position (0% open), and documented on the PFCT forms.

6) Verification of all local equipment control points integrated to the BAS via network interface communications (e.g., BACnet, Modbus, etc.), including both read only and writable points.

f. Submit the completed BAS and HVAC System Controls IV and PFCT forms for review by the CxA.

g. The BAS and/or the Mechanical Trade Subcontractor shall support commissioning by participating in the BAS and HVAC System Controls IV and PFCT Field Review & Back-check, in which the BAS and/or the Mechanical Trade Subcontractor reviews and demonstrates specified results to the CxA, after completing and submitting the BAS and HVAC System Controls IV and PFCT forms.

1) The BAS and HVAC System Controls IV and PFCT Field Review & Back-check shall include field review of the control system sensor / device installations and live readings, and also field demonstrations (back-check) of the pre-functional checks and tests performed by the Trade Subcontractors and witnessed by the CxA, for an approximate 10% to 30% sample, to be selected by the CxA for each major system, or what can be accomplished in 1 full day.

2) Any Cx issues reported by the CxA shall be reviewed and addressed by the BAS and Mechanical Trade Subcontractors, and if required, the PFCT forms shall be revised and resubmitted, prior to performing any FPTs.

h. The BAS Controls and Mechanical Trade Subcontractor shall configure all BAS or local control graphics and programming logic for the sequence of operations and associated setpoints, schedules, and alarms and verify the system operation, including the control loop tuning, prior to starting FPTs.
Prior to conducting the CxA witnessed FPTs, place the systems and controls into the operating modes intended for testing. Check all control system safety cutouts, alarms, and interlocks with smoke control and fire-life safety during each mode of operation prior to functional testing. Ensure all systems are operating and performing per the requirements of the contract and design documents, and have been pre-tested per the FPTs, and are ready for the CxA witnessed FPTs.

1) The Trade Subcontractors shall determine the appropriate level of pre-testing, to prepare for the CxA witnessed FPTs.

j. The BAS Trade Subcontractors shall provide any necessary control system global or system level commands and setpoint adjustments necessary to conduct the testing as called out in the FPT procedures.

k. The BAS Trade Subcontractor shall set up the appropriate trends per the Trend Setup Verification forms provided by the CxA and shall provide trend data into a usable electronic format files, such as a text, CSV or Excel format, to the CxA. The CxA will analyze and review the trend data as part of the FPT. These trends shall be setup prior to conducting any sequence of operation functional tests.

1) The trend points list may include both hardware (inputs, outputs) and virtual / software points.
2) The appropriate trend intervals and minimum duration will be provided by the CxA either in a Trend Setup Verification form or in the FPT forms.
3) As an Owner approved alternative, the BAS Trade Subcontractor may provide the CxA remote access to the control system, with Owner permission, that will allow the CxA to easily and directly download the trend data files.

l. The BAS Trade Subcontractor shall also provide trend data to the CxA during the post-occupancy warranty phase for review by the CxA, where required.

m. Participate in any applicable integrated whole building tests under emergency power. This test is initiated by disconnecting the utility power to the building, and it will involve multiple disciplines. All Trade Subcontractors shall participate in the FPTs as required for operation of the inter-related systems.

G. Trade Subcontractors – Specific TAB Requirements

1. In addition to the Trade Subcontractor responsibilities outlined above, the TAB Trade Subcontractor responsibilities during commissioning shall include, but are not limited to:

a. Submit a TAB Plan and Qualifications to the Design Professional and CxA for review, at least 4 weeks in advance of conducting any required TAB work, in addition to any other submittal requirements per the specifications. Electronic files are acceptable. The TAB Plan and Qualifications shall include the following:

1) An outline of the TAB procedures and approach for each system type. The TAB procedures and approach shall satisfy the contract documents and TAB specifications. If TAB procedures and approach are not defined in the contract documents or TAB specifications, then the TAB procedures and approach shall meet the requirements of NEBB Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems Section 7.3 (Preliminary TAB Procedures) and/or AABC National Standards Section 20.4 (Procedures).
2) A project specific list of the BAS control sequence of operation setpoints that will be determined by TAB, and the associated specific procedures to determine the BAS setpoints. The TAB Trade Subcontractor shall coordinate with the BAS Trade Subcontractor to obtain and review the sequence of operation.
3) The associated TAB forms and the drawings to be used in the TAB work. It’s recommended that the forms be pre-filled with all available project, site, and design parameters.
4) TAB contractor qualification certificates.
5) TAB instrument calibration certificates.

b. Provide access for the CxA to witness TAB work. Notify the CxC and CxA at least 10 days in advance of TAB work.
   1) Immediately report any issues and deficiencies discovered which may affect or delay the commissioning process.

c. Submit a Draft / Preliminary TAB Report with the completed field forms and data to the Design Professional and CxA for review, within 72 hours following completion of the TAB, and prior to any TAB Field Review & Back-check conducted with the CxA, and prior to conducting the FPTs. Respond to and address comments provided by the DP and CxA.

d. The TAB Trade Contractor shall support commissioning by participating in the commissioning TAB Field Review & Back-check, in which the TAB Trade Contractor demonstrates specified results to the CxA, after completion of the Draft TAB Report.
   1) The TAB Field Review & Back-check shall include field demonstrations of any final setpoints and back-check measurements of the air-side and water-side systems, performed by the TAB Trade Contractor and witnessed by the CxA and/or the Design Professional, for an approximate 10% to 30% sample to be selected by the CxA, or what can be accomplished in 1 full day.
   2) If the back-checks yield results that are outside the TAB tolerances for more than 10% of the sample, the TAB shall be considered incomplete.
   3) The TAB Field Review & Back-check measurements shall be recorded on the Final TAB Report or a separate form or appendix attached to the Final TAB Report, for documentation purposes.

e. Submit the Final TAB Report to the Design Professional and CxA for review after review of the Draft TAB Report and completion of TAB Field Review.

1.9. SUBMITTAL REQUIREMENTS FOR COMMISSIONING

A. Trade Subcontractor Commissioning Forms. The Trade Subcontractors shall submit to the CxA all applicable representative, blank forms and plans for IV, Startup and PFCT tasks for the project (as listed in 1.8 Trade Subcontractor Responsibilities), at least 4 weeks in advance of performing any of these tasks.
   1. The draft SRC forms issued by the CxA will list the required IV, Startup and PFCT forms and plans, required for this project. The Trade Subcontractor shall review the draft SRCs to ensure all applicable, representative IV, Startup and PFCT forms and plans have been submitted for the CxA review.
   2. The CxA will review these submitted commissioning forms including whether all project specific requirements are included.
   3. The CxA may request additional data, changes and/or additions to these forms to confirm application prior to their use. If the Trade Subcontractor cannot submit sufficient forms, the CxA will provide forms based on the construction documents and specifications, manufacturer installation manuals and procedures, and/or industry standards or guidelines.

B. Training Agenda. The Trade Subcontractors shall develop a Training Agenda for each training session, per the requirements of the contract documents and specifications, and the LEED Enhanced Commissioning requirements, and may include both operations and maintenance (O&M) staff training and occupant training. The Training Agenda shall be included in the comprehensive Training Plan to be submitted by the GC for review by the CxA, Design Professionals, and/or the Owner (see Section 01910, General Commissioning Requirements). The GC and Trade Subcontractors shall coordinate to fully develop the comprehensive Training Plan with input from the Owner.
1. The Training Agenda for each training session shall include the following:
   a. equipment and/or systems covered;
   b. recommended attendees;
   c. proposed location;
   d. estimated duration;
   e. level of instruction to be provided and an outline of the training topics and subjects to be covered;
   f. list of any materials and handouts to be provided (or provided in advance);
   g. company to provide the training and the instructor’s name and qualifications.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1. MEETINGS, SCHEDULING AND COORDINATION
   A. See Section 01910, General Commissioning Requirements.

3.2. DOCUMENTATION
   A. The Trade Subcontractors have specific responsibilities for assisting in the development of equipment check, test and verification procedures and forms, and in performing and documenting commissioning tests, as directed by the CxC and as overseen by the CxA.
   B. The Trade Subcontractors shall provide, wherever the Contract Documents require, system checks and testing, test reports, factory test data and reports, checklists, operational verifications and demonstration, etc., whether specified or not in the commissioning sections.

3.3. TEST EQUIPMENT
   A. The Trade Subcontractor shall provide all test equipment in sufficient quantities to execute all Pre-Functional and Functional Performance Tests in an expedient fashion.
   B. The test equipment shall be of industrial quality and suitable for testing and calibration with accuracy within the tolerance necessary to demonstrate system performance per the Contract Documents. If not otherwise specified, the following minimum requirements apply:
      1. Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5 degree F and a resolution to + or – 0.1 degree F.
      2. Pressure sensors shall have an accuracy of + or – 2.0 percent of the value range being measured (not full range of meter) and have been calibrated within the last year.
   C. The test equipment shall have calibration certification per equipment manufacturer’s interval level or within one year if not otherwise specified. The calibration tags shall be affixed or certificates readily available for all test equipment.

3.4. SYSTEM READINESS: INSTALLATION VERIFICATION, STARTUP, PRE-FUNCTIONAL CHECKS & TESTS
A. The Trade Subcontractors shall conduct all startup procedures and tests without compromise to human or equipment safety. The GC and Trade Subcontractors shall be responsible for the liability and safety of conducting all startup, checks and tests.

B. The Trade Subcontractors shall clearly identify and list any issues and deficiencies resulting from the IV, Startup and PFCT tasks on the associated forms and immediately notify the CxA. The CxA will additionally document the issues on the Cx Log. Once issues and deficiencies are corrected and verified, the associated forms shall be updated and resubmitted, and any necessary field review, back-checks or re-tests witnessed by the CxA.

C. The CxC and Trade Subcontractors shall provide a minimum 10 days’ notice to the CxA for witnessing equipment Startup and PFCT tasks.
   1. The sample rates for the CxA witnessing of duct and pipe system PFCT tasks and equipment startups, will be defined in the Cx Plan. For most tasks, the CxA will witness the first test for any applicable duct and/or supply plenum leakage testing and the first startup for each main equipment type.
   2. For the BAS Pre-Functional Checks and for TAB, the CxA will witness a Field Review & Back-check of each, as described in Part 1, Paragraph 1.8.

D. The GC and Trade Subcontractors shall ensure the completion of the SRC forms. Review and approval of the completed SRC forms by the CxA is required prior to conducting the FPTs.

3.5. FUNCTIONAL PERFORMANCE TESTS

A. The Trade Subcontractors shall perform all FPTs per the final FPT forms and complete the Title 24 Part 6 acceptance test requirements and Certificate of Acceptance forms, for all systems and equipment in the scope of commissioning. The FPTs shall be witnessed by the CxA. The Trade Subcontractors may need to complete off hours or weekend work in order to complete the FPTs.

B. The CxA will document all testing results on the FPT forms, not including the Title 24 Certificate of Acceptance forms. The completion of the Title 24 Certificate of Acceptance forms is a contractor responsibility.

C. As outlined in the Part 1 general commissioning process, a sampling approach shall be used for the FPTs of identical systems and equipment, using the sample rates as defined in the Cx Plan, with the specific systems and equipment selected by the CxA.

D. The Trade Subcontractors shall determine what level of pre-testing is appropriate in order to prepare for the CxA witnessed FPTs.

E. The CxC and Trade Subcontractors shall coordinate all FPTs with the CxA, and provide a minimum of 10 days’ notice prior to conducting each test.

F. The GC and Trade Subcontractors shall have responsibility for the liability and safety of conducting all functional performance tests.

G. The Trade Subcontractor executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. to execute the test according to the test procedures.
   1. The Trade Subcontractors shall provide any necessary control system global or system level commands and setpoint adjustments necessary to conduct the testing as called out in the FPT procedures. For example, globally adjusting the space temperature setpoints for
all terminal units on a floor or AHU or the building. Or as another example, globally overriding the economizer status command for all AHUs.

H. At completion of the test, the Trade Subcontractor shall return all affected building equipment and systems to their pre-test normal condition.

3.6. FUNCTIONAL PERFORMANCE TESTS – TREND ANALYSIS

A. The CxA may conduct trend analysis as part of the FPT process, after completion of the onsite field conducted FPTs and correction of all issues and deficiencies, to verify integrated system operation and performance.

B. The CxA will prepare a BAS trend points list including the trend interval. The BAS Trade Contractor shall set up the trend log definitions prior to the start of the sequence of operation FPTs.

C. The BAS Trade Subcontractor shall provide the trend to the CxA in an electronic format, either a text file, CSV file or Excel file, with related system parameters grouped together. The estimated duration for the trend data is 1 to 3 weeks (with a minimum of 1 weeks' worth of data).

D. If the CxA discovers any control or performance issues during trend analysis, the Trade Subcontractors shall correct the issues and provide new trend data for analysis verification by the CxA.

3.7. COMMISSIONING ISSUES, BACK-CHECKS AND RE-TESTS

A. When Cx issues are identified during testing, the CxA will discuss with the executing Trade Subcontractor and/or CxC and determine whether or not testing can proceed. The CxA may allow immediate correction of minor issues and deficiencies identified during testing. The Cx issue and any identified resolution will be documented on the test form in use in addition to the Cx Log.

B. The CxA will maintain and update the Cx Log, and document the issue resolution process. Copies will be distributed to the GC, Owner, and Trade Subcontractors as appropriate. The Trade Subcontractors shall provide updates and comments regarding issue status and resolution.

C. The Trade Subcontractors shall promptly correct all Cx issues. The responsible party shall correct the issue and inform the CxC and CxA of the resolution and completion date, and update the Cx Log accordingly (in the fields assigned for contractor updates).

D. The CxA will record completion on the Cx Log after a successful witnessed re-test, field review, back-check, verification obtained through appropriate documentation or photographs, or acceptance by the Design Professional or Owner. The CxC shall reschedule any applicable re-testing with the CxA and Trade Subcontractor. The Trade Subcontractor shall retest until achievement of passing performance or Owner acceptance of the noted issue.

1. Where sampling is used for the PFCTs and FPTs, the results shall be deemed acceptable once all noted issues are resolved and any new sample tests or checks have passed.

E. Additional parties may require input during a dispute regarding a Cx issue. Regardless of the validity or responsibility of the issue, the CxA will have the final interpretive authority on Cx issues and the Owner will have the final approval authority.

F. The CxA may recommend solutions to Cx issues. However, the GC and Trade Subcontractors ultimately have the burden of responsibility to solve, correct and perform required retests.
G. Back-checks, Verifications and Re-testing:
   1. The CxA will witness one (1) re-test or will perform one (1) field back-check or verification of any Cx issue.
   2. The CxA’s total onsite time for re-test witnessing and field verification or back-check of Cx issues will be limited to no more than 2 work days (full 8-hour work days) for all applicable systems in the commissioning scope.
   3. The Owner may back-charge the GC for any additional fees from the CxA, resulting from any additional re-testing or field back-checks or verification beyond this allocated total time.
   4. The CxC must provide a minimum 48 hours’ notice for scheduling any re-testing, though the CxA will attempt to accommodate a shorter timeframe if feasible.
   5. Any required re-testing shall not be considered a justified reason for a claim of delay or for a time extension.

H. For any re-testing required, the CxA will determine if the entire test must be re-tested or if it is acceptable to re-test specific portions of the test that had failed.

3.8. DEFERRED & SEASONAL TESTING

A. Before or during the end of the first year warranty period, the Trade Subcontractor shall complete any seasonal or deferred testing, required per the design specifications and as defined in the Cx Plan. The Trade Subcontractors shall complete tests in the same manner as all other commissioning tests, including CxA witnessing.

B. The CxC and Trade Subcontractor shall coordinate with CxA and Owner and schedule all deferred and seasonal testing.

3.9. TRAINING VERIFICATION

A. The CxC and Trade Subcontractors shall coordinate and schedule the training for the Owner’s facility and operations personnel, and building occupants. The CxC shall ensure that training is completed per the requirements of the contract documents and specifications.

B. Trade Subcontractors responsible for specific equipment and system training shall submit to the CxC, a written training agenda for each training class for the equipment and systems to be commissioned. The GC shall submit a comprehensive Training Plan, including the specific training agendas, to Owner, Design Professionals and CxA for review and approval. See also Section 01910, General Commissioning Requirements.

C. The CxA will review the Training Plans for commissioning verification prior to conducting the actual training.

D. For verification of actual training conducted, the CxC shall submit to CxA ‘attendee signed’ attendance sheets for each training session conducted and a copy of any final training presentations or handout materials.

3.10. COMMISSIONING ACCEPTANCE, CLOSE-OUT AND REPORTING

A. Completion of the main commissioning activities (system readiness checks, functional performance testing, and training) shall be accomplished as a prerequisite for substantial completion. Completion of any re-testing shall be completed prior to final acceptance of commissioning.
B. After completion of the main commissioning activities and following review of the completed commissioning documents, test results and the current Cx Log with the Owner, the Owner will indicate whether they accept completion of the project construction phase commissioning or if not, the requirements for acceptance. Upon Owner acceptance, any remaining open Cx issues will be transferred to the warranty phase Cx Log for tracking resolution and completion as part of the warranty phase commissioning.

C. Upon completion of all commissioning activities, the CxA will prepare and submit to the Owner a Cx Report detailing all completed commissioning activities and documentation. The CxC shall support this effort by providing all GC and Trade Subcontractor commissioning documentation.

D. The CxA will complete a Systems Manual for the systems and equipment commissioned, following the LEED requirements, with assistance provided by the CxC and Trade Subcontractors. The Systems Manual will provide the operating staff the information needed to understand and optimally operate the commissioned systems. It will also include the current facility requirements, O&M preventative maintenance information, and an ongoing commissioning plan. Per LEED enhanced commissioning requirements, the Systems Manual will contain the following sections and detail:

1. Current facility requirements including the final version of the BOD and systems narrative.
2. Final equipment list.
3. Systems single line diagrams or schematics.
4. Final as-built sequence of operations, control drawings (P&IDs), points lists and setpoints.
5. Additional operating instructions for key systems or integrated building systems such as water-side and air-side HVAC systems and controls, lighting controls, etc.
6. Recommended schedule of major preventative maintenance requirements and frequency.
7. Ongoing Cx Plan
   a. Definition of the ongoing commissioning process, defined roles and responsibilities, a recommended schedule for recommissioning the systems;
   b. Recommended schedule for retesting of commissioned systems with blank test forms from the Final Commissioning Plan.
   c. Recommended schedule for calibrating sensors and actuators.

3.11. POST-OCCUPANCY WARRANTY PHASE COMMISSIONING

A. The Trade Subcontractors shall execute any defined seasonal or deferred FPTs, witnessed by the CxA.

B. The CxA may review BAS trend data during the Warranty Phase. The BAS Trade Contractor shall be responsible for providing post-occupancy trend data to the CxA.

C. The CxA will report any identified issues and recommendations to the CxC via a Warranty Phase Cx Log for review and resolution by the GC and Trade Subcontractors prior to the end of the warranty period, for any issues or recommendations identified either by the CxA or the Owner. The CxC shall work with the Trade Subcontractors and O&M staff to make corrections and adjustments as required to address the issues and recommendations.

D. Key representatives from the GC and Trade Subcontractors shall attend a near end of warranty commissioning review meeting, to be scheduled with the Owner’s facility staff and the CxA, no later than either 10 months after substation completion or two months prior to the expiration of the first 12-month warranty period of building occupancy.

1. During this meeting, the operation of the systems will be discussed with the Owner’s staff, the results of any commissioning trend analysis will be reviewed and the Warranty Phase
Cx Log will be reviewed. If needed, a walk-through of the systems with the Owner’s staff will be conducted.

2. Next steps and actions items for any open Cx issues and recommendations will be discussed and documented via meeting minutes or a field report issued by the CxA. The intent is to resolve any open Cx issues prior to the end of the warranty phase.

E. After correcting noted Warranty Phase Cx issues, the CxC shall notify the CxA, and the CxA will back-check and verify resolution of the issues and recommendations.

F. Issues identified during the warranty period will remain warranty phase Cx issues until satisfactory completion by Trade Subcontractors, even if the warranty period expires during the correction and back-check period.

END OF SECTION
SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. SECTION INCLUDES

1. Chilled and Heating Hot Water piping, above grade.
2. Chilled and Heating Hot Water piping, buried.
3. Pipe hangers and supports.
4. Unions, flanges, mechanical couplings, and dielectric connections.

B. Related Requirements:

1. Section 230523 “General Duty Valves for HVAC Piping”.
2. Section 232116 “Hydronic Piping Specialties”.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Pipe.
2. Fittings.

B. Sustainable Design Submittals:

1. Product Data: For adhesives, indicating VOC content.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Other building services.
3. Structural members.
4. Interior wall and soffit framing

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.
1.5 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint
      manufacturer as having been trained and qualified to join piping with pressure-seal pipe
      couplings and fittings.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M,
   "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel
   Code: Section IX.
   1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and
      installation.
   2. Certify that each welder has passed AWS qualification tests for welding processes involved
      and that certification is current.
   3. Certificate described above is not valid unless it has been issued while welder was working
      for his current employer, and unless welder has performed type of work described by
      certificate in preceding 3 months.

D. The Owner's Representative reserves the right to test the work of any welder employed on the
   project, at the Owner's expense. If the work of the welder is found to be unsatisfactory, the welder
   shall be prevented from doing further welding on the project and all defective welds replaced.

E. The Owner may, at the Owner's expense, initially x-ray inspect welds in accordance with ANSI
   B31.9. Welds not in conformance will be replaced by the contractor at his expense. Costs of x-
   raying the new weld will be borne by the contractor.

1.6 WARRANTY

A. Manufacturer shall warrant pipe and fittings for 10 years to be free of defects in materials or
   workmanship.

B. Warranty shall cover labor and material costs of repairing and/or replacing defective materials
   and repairing any incidental damage caused by failure of the piping system due to defects in
   materials or workmanship.

PART 2 - PRODUCTS

2.1 HYDRONIC SYSTEM REQUIREMENTS

A. Comply with ASME B31.9 and applicable federal, state, and local regulations.

B. Piping: Provide piping, fittings, hangers and supports as required, as indicated, and as follows:
   1. Where more than one piping system material is specified, provide joining fittings that are
      compatible with piping materials and ensure that the integrity of the system is not
      jeopardized.
   2. Use non-conducting dielectric connections whenever jointing dissimilar metals.
   3. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless
      indicated otherwise.
4. Pipe elbows shall be long radius (1.5 diameter fittings).

C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges, unions, or grooved couplings to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.

D. Valves: Provide valves where indicated.

E. Piping shall be made in America.

F. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
   1. Heating Hot Water Heating Piping: 125 psig at 200 deg F.
   2. Chilled Water Piping: 150 psig at 120 deg F.
   3. Condensate-Drain Piping: 120 deg F.
   4. Air-Vent Piping: 200 deg F.
   5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B).

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Fittings and Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.


D. Malleable-Iron Unions: ASME B16.39; Classes 150, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   2. End Connections: Butt welding.
2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

A. Unions for Pipe 2 inches and Under:

B. Flanges for Pipe Over 2 inches:

C. Mechanical Couplings for Grooved and Shouldered Joints: Two or more curved housing segments with continuous key to engage pipe groove, circular C-profile gasket, and bolts to secure and compress gasket.
   1. Dimensions and Testing: In accordance with AWWA C606.
   2. Mechanical Couplings: Comply with ASTM F1476.
   4. When pipe is field grooved, provide coupling manufacturer’s grooving tools.

D. Dielectric Connections: Red brass dielectric nipple.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.

C. Remove scale and dirt on inside and outside before assembly.

D. Prepare piping connections to equipment using jointing system specified.

E. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
3.2 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Pipe elbows shall be long radius (1.5 diameter fittings).

C. Route piping in orderly manner, parallel to building structure, and maintain gradient.

D. Install piping to conserve building space and to avoid interfere with use of space.

E. Group piping whenever practical at common elevations.

F. Slope piping and arrange to drain at low points.

G. Install piping to permit valve servicing.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install unions in piping, NPS 2-1/2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

K. Install flanges in piping, NPS 3 and larger, at final connections of equipment and elsewhere as indicated.

L. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

M. Install shutoff valve immediately upstream and downstream of each dielectric fitting.

N. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

O. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

P. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Division 01.

Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230000.

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230000.

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230000.
3.3 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gauges for HVAC Piping."

3.4 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:
   1. Open valves to fully open position. Close coil bypass valves.
   2. Check pump for proper direction of rotation.
   3. Set automatic fill valves for required system pressure.
   4. Check air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
   5. Set temperature controls so all coils are calling for full flow.
   6. Check operation of automatic bypass valves.
   7. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
   8. Lubricate motors and bearings.

3.5 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
   2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
   4. Spring hangers to support vertical runs.
   5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe, or steel hangers with felt insert.

D. Install hangers for steel piping with the following maximum spacing 3/8 inch minimum rod size:
   1. NPS 3/4: Maximum span, 10 feet.
   2. NPS 1: Maximum span, 12 feet.
   3. NPS 1-1/2: Maximum span, 12 feet.
   4. NPS 2: Maximum span, 12 feet.
5. NPS 2-1/2: Maximum span, 12 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and 3/8 inch minimum rod sizes:
   1. NPS 3/4: Maximum span, 6 feet.
   2. NPS 1: Maximum span, 6 feet.
   3. NPS 1-1/4: Maximum span, 6 feet.
   4. NPS 1-1/2: Maximum span, 6 feet.
   5. NPS 2: Maximum span, 10 feet.
   6. NPS 2-1/2: Maximum span, 10 feet.
   7. NPS 3 and Larger: Maximum span, 10 feet.

3.6 CLEANING

A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

3.7 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:
   1. Leave joints, including welds, uninsulated and exposed for examination during test.
   2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   3. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
   4. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:
   1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
   2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
   3. Isolate expansion tanks and determine that hydronic system is full of water.
   4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
   5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
   6. Prepare written report of testing.

C. Perform the following before operating the system:
   1. Open manual valves fully.
   2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

3.8 PIPE SCHEDULE

<table>
<thead>
<tr>
<th>Service</th>
<th>Location</th>
<th>Size</th>
<th>Material</th>
<th>Fittings</th>
<th>Joining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Hot</td>
<td>Above Ground</td>
<td>Up to 3&quot;</td>
<td>CU-L</td>
<td>Wrought Copper</td>
<td>Soldered</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Up to 3&quot;</td>
<td>Steel</td>
<td>Mallable Iron</td>
<td>Threaded / Welded</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4&quot; &amp; above</td>
<td>Steel Sch 40</td>
<td>Wrought Steel</td>
<td>Threaded / Welded</td>
</tr>
<tr>
<td></td>
<td>Mechanical Rooms</td>
<td>All</td>
<td>Steel Sch 40</td>
<td>Grooved</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Chilled Water</td>
<td>Above Ground</td>
<td>Up to 3&quot;</td>
<td>CU-L</td>
<td>Wrought Copper</td>
<td>Soldered</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Up to 3&quot;</td>
<td>Steel</td>
<td>Mallable Iron</td>
<td>Threaded / Welded</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4&quot; &amp; above</td>
<td>Steel Sch 40</td>
<td>Wrought Steel</td>
<td>Threaded / Welded</td>
</tr>
<tr>
<td></td>
<td>Mechanical Rooms</td>
<td>All</td>
<td>Steel Sch 40</td>
<td>Grooved</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Makeup Water</td>
<td>All</td>
<td>All</td>
<td>CU-L</td>
<td>Wrought Copper</td>
<td>Soldered</td>
</tr>
<tr>
<td>Condensate</td>
<td>All</td>
<td>All</td>
<td>CU-L</td>
<td>DWV</td>
<td>Soldered</td>
</tr>
<tr>
<td>Air Vent</td>
<td>All</td>
<td>All</td>
<td>CU-K</td>
<td>N/A</td>
<td>Flared</td>
</tr>
<tr>
<td>Safety Vent</td>
<td>All</td>
<td>All</td>
<td>CU-L</td>
<td>DWV</td>
<td>Soldered</td>
</tr>
</tbody>
</table>

END OF SECTION
**SECTION 232116 - HYDRONIC PIPING SPECIALTIES**

**PART 1 - GENERAL**

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes special-duty valves and specialties for the following:
   2. Relief valves.
   3. Air vents.
   4. Air separators.
   5. Expansion tanks.
   7. Strainers.
   8. Pressure-temperature test plugs.
   9. Connectors.

B. Related Requirements:
   1. Section 230523 “General Duty Valves for HVAC Piping”.
   2. Section 232113 “Hydronic Piping”.
   3. Division 25 for automatic control valve and sensor specifications, installation requirements, and locations.

1.3 ACTION SUBMITTALS

A. Operation and Maintenance Data: to include in emergency, operation, and maintenance manuals.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
PART 2 - PRODUCTS

2.1 BALANCING VALVES

A. Manufacturers:
   1. Armstrong International, Inc
   2. ITT Bell & Gossett
   3. Taco, Inc.

B. Bronze, Calibrated-Orifice, Balancing Valves:
   1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
   2. Ball: Brass or stainless steel.
   3. Plug: Resin.
   4. Seat: PTFE.
   5. End Connections: Threaded or socket.
   7. Handle Style: Lever, with memory stop to retain set position.
   8. CWP Rating: Minimum 125 psig.
   9. Maximum Operating Temperature: 250 deg F.

C. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
   1. Body: Cast-iron or steel body, ball or butterfly pattern with calibrated orifice or venturi.
   2. Ball: Brass or stainless steel.
   4. Disc: Glass and carbon-filled PTFE.
   5. Seat: PTFE.
   6. End Connections: Flanged or grooved.
   8. Handle Style: Lever, with memory stop to retain set position.
  10. Maximum Operating Temperature: 250 deg F.

2.2 RELIEF VALVES

   1. Manufacturers:
      a. Tyco Flow Control.
      b. Armstrong International, Inc.
      c. ITT Bell & Gossett.
   2. Body: Bronze or brass.
   3. Disc: Glass and carbon-filled PTFE.
   5. Stem Seals: EPDM O-rings.
   6. Diaphragm: EPT.
   9. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
2.3 AIR VENTS

A. Manufacturers:
   1. Armstrong International, Inc
   2. ITT Bell & Gossett
   3. Taco, Inc.

B. Manual Air Vents:
   1. Body: Bronze.
   2. Internal Parts: Nonferrous.
   3. Operator: Screwdriver or thumbscrew.
   4. Inlet Connection: NPS 1/2.
   7. Maximum Operating Temperature: 225 deg F.

C. Automatic Air Vents:
   1. Body: Bronze or cast iron.
   2. Internal Parts: Nonferrous.
   4. Inlet Connection: NPS 1/2.
   7. Maximum Operating Temperature: 240 deg F.

2.4 EXPANSION TANKS:

A. Bladder-Type Expansion Tanks:
   1. Manufacturers:
      a. Amtrol Inc.
      b. ITT Bell & Gossett.
      c. Taco, Inc.
   2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
   5. Tank drain.

2.5 BUFFER TANKS

A. Manufacturers:
   1. Wessels.
   2. Niles Steel Tank.

B. Tank: Welded steel, rated for 125-psig working pressure. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
1. Provide drain.

C. Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure. Lifting lugs.

2.6 AIR SEPARATORS:

A. In-Line Air Separators:
1. Manufacturers:
   b. ITT Bell & Gossett.
   c. Taco, Inc.
2. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
4. Maximum Operating Temperature: Up to 300 deg F.

2.7 STRAINERS

A. Y-Pattern Strainers:
1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
4. CWP Rating: 175 psi.

B. Grooved Joint Strainers:
1. Body: ASTM A536, ductile iron with access cap.
2. Coupling Gasket: Grade E EPDM.
3. Strainer Screen: Type 304 stainless-steel perforated screen.
4. CWP Rating: 750 psi.
5. Horizontal or vertical mounting.
6. Use with Grooved Joint System only.

2.8 PRESSURE-TEMPERATURE TEST PLUGS

A. Construction: Brass body designed to receive temperature or pressure probe with removable protective cap, and EPDM rated for minimum 200 deg F.

B. Use extended length plugs to clear insulated piping.

2.9 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:
2. End Connections: Threaded or flanged to match equipment connected.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

D. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

E. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

F. Install strainers on supply side of each control valve, pressure reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS ¾ nipple and ball valve in blow-down connection of strainers NPS 2 and larger. Match size of strainer blow-off connection for strainers smaller than NPS 2.

END OF SECTION
SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section Includes:
   B. Related Requirements:
      1. Section 230523 “General Duty Valves for HVAC Piping”.
      2. Section 232113 “Hydronic Piping”.
      3. Section 232116 “Hydronic Piping Specialties”.

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump’s operating point on curves.
   B. Shop Drawings: For each pump.
      1. Show pump layout and connections.
      2. Include setting drawings with templates for installing foundation and anchor bolts and otheranchorages.
      3. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS
   A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
      1. Mechanical Seals: One mechanical seal(s) for each pump.
PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Manufacturers:
   1. Armstrong Pumps Inc.
   2. ITT Bell & Gossett.
   3. Taco.

B. Provide pumps that operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

C. Listed and classified by UL or testing agency acceptable to authority having jurisdiction as suitable for the purpose specified and indicated.

D. Motors: Include built-in, thermal-overload protection and grease-lubricated ball bearings. Select each motor to be nonoverloading over full range of pump performance curve. See Section 23 05 13 “General Motor Requirements for HVAC”.

E. Coupling: Where a variable frequency drive is specified, provide a pump coupling rated for reduction in operational speed down to 25% (15 Hz).

2.2 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

A. Description: Factory-assembled and tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

B. Pump Construction:
   1. Casing: Radially split, cast iron, with drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and flanged connections.
   2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw.
   4. Seal: Mechanical seal, 225 deg F maximum continuous operating temperature.
   5. Pump Bearings: Permanently lubricated ball bearings.
   6. Baseplate: Cast iron or fabricated steel with integral drain rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION
A. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
C. Equipment Mounting:
   1. Install pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 03.
   2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 “Vibration and Seismic Controls for HVAC.”

3.3 CONNECTIONS
A. Where installing piping adjacent to pump, allow space for service and maintenance.
B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
D. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
E. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.
F. Ground equipment according to Division 26.
G. Connect wiring according to Division 26.

3.4 STARTUP SERVICE
A. Perform startup service
   1. Complete installation and startup checks according to manufacturer’s written instructions.
   2. Check piping connections for tightness.
   3. Clean strainers on suction piping.
   4. Perform the following startup checks for each pump before starting:
      a. Verify bearing lubrication.
      b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
      c. Verify that pump is rotating in the correct direction.
   5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
7. Open discharge valve slowly.

3.5 DEMONSTRATION

A. Train Owner’s maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION
SECTION 232500 - HVAC WATER TREATMENT

PART 1 – GENERAL

1.1 SUMMARY
   A. Section includes the following HVAC water-treatment systems:
      1. Chemical-feed equipment and controls.

1.2 ACTION SUBMITTALS
   A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for chemical treatment equipment, materials, and chemicals.
   B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, attachment details and diagrams for power and control wiring.

1.3 INFORMATIONAL SUBMITTALS
   A. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
   B. Field quality-control reports.
   C. Other Informational Submittals:
      1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.

1.4 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For chemical treatment system to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE
   A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

1.6 WARRANTY
   A. Warranty Period: Two years from date of Substantial Completion on equipment.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or to the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems:
   1. Sequestering agent to reduce deposits and adjust pH; polyphosphate.
   2. Corrosion inhibitors; boron-nitrite, sodium nitrite and borax, sodium tolyltriazole, low molecular weight polymers, phosphonates, sodium molybdate, or sulphites.
   3. Conductivity enhancers; phosphates or phosphonates.

2.2 CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

2.3 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
C. Install water-testing equipment on wall near water-chemical-application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Bypass Feeders: Install in closed hydronic systems and equipped with the following:
   1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
   2. Install water meter in makeup-water supply.
   3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
   4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
   5. Install a swing check on inlet after the isolation valve.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet.

E. See Division 22 for backflow preventers required in makeup-water connections to potable-water systems.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
   2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
   3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC system's startup procedures.
   4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
   5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
   7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and
allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.

8. Repair leaks and defects with new materials and retest piping until no leaks exist.

C. Equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. At six-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to "Performance Requirements" Article.

3.5 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
5. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

END OF SECTION
SECTION 233100 – HVAC METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Ducts and fittings.
   2. Sheet metal materials.
   3. Casings.
   4. Flexible Ducts.
   5. Duct liner.
   7. Hangers and supports.
   9. Duct leakage testing.

B. Related Sections:
   1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
   2. Section 230713 "HVAC Duct Insulation".
   3. Section 233300 "Air Duct Accessories" for dampers, duct silencers, duct-mounting access doors and panels, turning vanes, and flexible connections.

1.3 PERFORMANCE REQUIREMENTS

A. Duct system has been design for low friction drop, both through straight duct and through fittings. Fitting types or duct sizes may be substituted only for those of equal to or lesser pressure drop, with written permission from engineer of record. Maximum duct aspect ratio shall be 3:1.
   a. Design pressure drop criteria:
      1) Supply, Return, Outside, and Transfer Air Ducts: maximum 0.05 in wg per 100 feet.
      2) Exhaust Air Ducts: maximum 0.08 in wg per 100 feet.
   b. Design velocity criteria:
      1) Outdoor ductwork or ductwork within a mechanical room: maximum 1,800 feet per minute.
      2) Ductwork in a shaft: 1,500 feet per minute.
      3) Indoor ductwork not within a mechanical room or shaft: maximum 1,200 feet per minute.
      4) Acoustical Consultant’s recommendations, which supersede above criteria.
      5) Exhaust ductwork: minimum 1,000 feet per minute or as required if fumes or particulate are being conveyed.
B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible", ASCE/SEI 7, and SMACNA’s "Seismic Restraint Manual: Guidelines for Mechanical Systems."

C. Casing Structural Performance:
   1. Casings shall be fabricated to withstand 133 percent of the indicated static pressure without structural failure. Wall and roof deflection at the indicated static pressure shall not exceed 1/8 inch per foot (1 mm per meter) of width.
   2. Fabricate outdoor casings to withstand wind load of 15 lbf/sq. ft. (720 N/sq. m) and snow load of 30 lbf/sq. ft. (1440 N/sq. m).

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
   1. Flexible ducts.
   2. Liners and adhesives.
   3. Sealants and gaskets.

B. LEED Submittals:
   1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - “Systems and Equipment.”
   2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - ”HVAC System Construction and Insulation.”
   3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - “Duct Leakage Tests.”
   4. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - ”Ventilation System Start-up.”
   5. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
   6. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services’ "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers.”

C. Shop Drawings:
   1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   2. Factory- and shop-fabricated ducts, casings, and fittings.
   3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
   4. Elevation of top of ducts.
   5. Dimensions of main duct runs from building grid lines.
   6. Fittings.
   7. Reinforcement details and spacing.
   8. Seam and joint construction and sealing.
   9. Penetrations through fire-rated and other partitions.
   10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, flexible connectors, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

D. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA (LEAK) – HVAC Air Duct Leakage Test Manual.
1. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS
A. Welding certificates.
B. Field quality-control reports.

1.6 QUALITY ASSURANCE
A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
B. Welding Qualifications: Qualify procedures and personnel according to the following:
C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
E. REGULATORY REQUIREMENTS
   1. Construct ductwork to NFPA 90A standards.
F. FIELD CONDITIONS
   1. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
   2. Maintain temperatures within acceptable range during and after installation of duct sealants.
   3. Ductwork shall be transported to the site in enclosed vehicles or with ends capped.
   4. Do not store ductwork directly on ground or floor.
   5. Ductwork stored or stacked on site shall be capped.
   6. Installed duct shall be capped at the end of the day. Duct found uncapped after the end of the day shall be cleaned.
1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with casings and plenums. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Transverse Joints in round ducts larger than 60 Inches (1524 mm) in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
   2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation (except as noted below): G60 (Z180).
   2. Galvanized Coating Designation for outside air intake ductwork, outdoor unjacketed ductwork, and as otherwise noted: G90 (Z275).
   3. Finishes for Surfaces Exposed to View: Mill phosphatized.
C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

D. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view. Aluminum Connectors and Bar Stock: Alloy 6061-T651 or of equivalent strength.

E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
   1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

G. Duct Closure Film: Mold-resistant, self-adhesive film to keep debris out of ducts during transportation and construction.
   1. Product: DynAir Duct Protection Film or equivalent.
   2. High tack water-based adhesive.
   3. Thickness: 2 mils.
   4. UV stability.
   5. VOC content: zero.
   6. Elongation before break: minimum 325%.

2.3 CASINGS

A. Description: Double-wall, insulated, pressurized equipment casing or plenum.

B. Wall Thickness: 2 inches (50 mm).

C. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 9, "Equipment and Casings," for acceptable materials, material thicknesses, and casing construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
   1. Fabricate casings with more than 3-inch wg (750-Pa) negative static pressure according to SMACNA's "Rectangular Industrial Duct Construction Standards."
   2. Casings with more than 2-inch wg (500-Pa) positive static pressure may be fabricated according to SMACNA's "Rectangular Industrial Duct Construction Standards."

D. Penetrations: Seal all penetrations airtight. Cover with escutcheons and gaskets, or fill with suitable compound so there is no exposed insulation. Provide shaft seals where fan shafts penetrate casing.

E. Access Doors: Fabricate access doors according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 9-15, "Casing Access Doors - 2-inch wg (500 Pa)," and Figure 9-16, "Casing Access Doors - 3-10-inch wg (750-2500 Pa); and according to pressure class of the plenum or casing section in which access doors are to be installed.
   1. Size: 24 by 54 inches (600 by 1370 mm).
3. Hinges: Piano or butt hinges and latches, number and size according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
4. Latches: Minimum of two wedge-lever-type latches, operable from inside and outside.
5. Neoprene gaskets around entire perimeters of door frames.
6. Reinforce door frames with steel angles tied to horizontal and vertical casing supporting angles.
7. Doors shall open against air pressure.
8. On doors of casings or plenums of 4 inch w.g. pressure or greater, provide sign reading “CAUTION – DOOR CLOSES WITH AIR PRESSURE”.

2.4 FLEXIBLE DUCTS

A. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.
   1. Manufacturers:
      a. Casco L-181M.
      b. Flexmaster USA 1NI.
      c. Thermaflex MC.
   2. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
   3. Maximum Air Velocity: 4000 fpm (20 m/s).
   4. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
   5. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
   6. NFPA 90A and NFPA 90B compliant.

B. Acoustically Rated, Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; vapor-barrier film.
   1. Manufacturers:
      a. Casco SF-181M.
      b. Flexmaster USA 1B.
      c. Thermaflex M-KE.
   2. Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
   3. Maximum Air Velocity: 4000 fpm (20 m/s).
   4. Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).
   5. Water Vapor Permeance: maximum 0.17 perms (ASTM E 96, Procedure A).
   6. Insulation R-Value: R-4.2 minimum at 70 deg F.
   7. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
   8. NFPA 90A and NFPA 90B compliant.

C. Flexible Duct Attachment:
   1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.
2.5 DUCT LINER

A. General Requirements:
1. No fiberglass duct liner is allowed.
2. Service temperature: -20 deg F to 250 deg F.
3. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
4. NFPA 90A and NFPA 90B compliant.
5. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

B. Polyester Duct Liner:
1. Manufacturers:
   a. Ductmate - PolyArmor.
   b. Or engineer-approved equivalent.
2. K value: ASTM C518, 0.24 at 75 deg F; R-value per inch: 4.2.
3. Minimum Noise Reduction Coefficient (NRC): 0.65 at 1 inch thickness.
4. Maximum moisture sorption: 2% by weight.
5. Minimum 25% recycled content.
7. Water-Based Liner Adhesive.

C. Polyamide Foam Duct Liner:
1. Manufacturers:
   b. Or engineer-approved equivalent.
2. K value: ASTM C518, 0.30 at 75 deg F; R-value per inch: 3.3.
3. Minimum Noise Reduction Coefficient (NRC): 0.70 at 1 inch thickness.
4. Maximum moisture sorption: 2% by weight.
5. Mechanical Fasteners:
   a. Suitable for attachment to duct without damaging liner as recommended by manufacturer.
   b. Pin length: as required. Pin shall project no more than 1/8 inch (3 mm) into air stream.

2.6 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723 (ASTM E84); certified by an NRTL.

B. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on or spray on.
2. Solids Content: Minimum 65 percent.
5. Mold and mildew resistant.
6. Volatile Organic Content (VOC): Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
8. Service: Indoor or outdoor.

C. Flanged Joint Sealant: Single-component, acid-curing, silicone, elastomeric. Comply with ASTM C 920, Type S, Grade NS, Class 25, Use O.
   1. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods: Cadmium-plated steel rods and nuts.

B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

D. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

E. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:
   3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.8 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
   1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
C. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

1. Basis of Design: Mason SCB.

D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of at least 1 inch (25 mm), plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

J. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements. Comply with ASTM A780.

3.3 CASING INSTALLATION

A. Install casings according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Equipment Mounting:
   1. Install HVAC casings on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Division 03.
   2. Anchor panels to concrete base on 8 inch centers and seal.
   3. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Apply sealant to joints, connections, and mountings.

D. Field-cut openings for pipe and conduit penetrations; insulate and seal according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Support components rigidly with ties, braces, brackets, seismic restraints, and anchors of types that will maintain housing shape and prevent buckling.

F. Align casings accurately at connections, with 1/8-inch (3-mm) misalignment tolerance and with smooth interior surfaces.

3.4 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
B. Building Attachments: Concrete inserts, expansion anchors, or structural-steel fasteners appropriate for construction materials to which hangers are being attached. Where practical, install concrete inserts before placing concrete.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install according to OSHPD OPM-0043013 as indicated on drawings.

B. Install cables so they do not bend across edges of adjacent equipment or building structure.

C. Install cable restraints on ducts that are suspended with vibration isolators.

D. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

F. Drilling for and Setting Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Set anchors to manufacturer's recommended torque, using a torque wrench.
   5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.
3.7 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 23 33 00 "Air Duct Accessories."

B. Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09.

3.9 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.
   1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
   2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
   3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:
   1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
   2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:
   1. Air outlets and inlets (registers, grilles, and diffusers).
   2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   3. Air-handling unit internal surfaces and components including mixing box, coil section, airwash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
   5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
   7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:
   1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
2. Test the following systems:
   a. Ducts with a Pressure Class of positive 3-Inch wg (750 Pa) or higher or negative 3-Inch wg (750 Pa) or lower: Test 100 percent of total installed duct area for each designated pressure class.
   b. Ducts with a Pressure Class between positive 2-Inch wg (500 Pa) and negative 2-Inch wg (500 Pa), inclusive: Test representative duct sections, selected by Design Engineer, totaling no less than 25 percent of total installed duct area for each designated pressure class.
   c. Risers and all supply and exhaust branch ducting shall be tested to within 5 feet of a diffuser collar or the point of connection to an exhaust device, respectively.
   d. Welded Exhaust Ducts: Test 100 percent of total installed duct area for each designated pressure class.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.11 DUCT SCHEDULE

**Table: Duct Schedule**

<table>
<thead>
<tr>
<th>Type</th>
<th>Material</th>
<th>Pressure Class</th>
<th>Rect. Leakage Class</th>
<th>Round Leakage Class</th>
<th>Seal Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Risers/Mains</td>
<td>Galvanized</td>
<td>+ 4&quot; w.g.</td>
<td>6</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>Supply, Before terminal boxes</td>
<td>Galvanized</td>
<td>+ 3&quot; w.g.</td>
<td>6</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>Supply, After terminal boxes</td>
<td>Galvanized</td>
<td>+ 2&quot; w.g.</td>
<td>6</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>Return</td>
<td>Galvanized</td>
<td>- 2&quot; w.g.</td>
<td>24</td>
<td>12</td>
<td>C</td>
</tr>
<tr>
<td>Transfer</td>
<td>Galvanized</td>
<td>- 1&quot; w.g.</td>
<td>24</td>
<td>12</td>
<td>C</td>
</tr>
<tr>
<td>Outside Air</td>
<td>Galvanized</td>
<td>- 2&quot; w.g.</td>
<td>24</td>
<td>12</td>
<td>C</td>
</tr>
<tr>
<td>Exhaust Riser/Mains and ductwork between exhaust plenum and fan (laboratory areas)</td>
<td>Galvanized</td>
<td>- 4&quot; w.g.</td>
<td>6</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>Exhaust, After terminal boxes (laboratory areas)</td>
<td>Welded Stainless Steel</td>
<td>- 3&quot; w.g.</td>
<td>12</td>
<td>6</td>
<td>B</td>
</tr>
<tr>
<td>Exhaust, Before terminal boxes (laboratory areas)</td>
<td>Welded Stainless Steel</td>
<td>- 2&quot; w.g.</td>
<td>12</td>
<td>6</td>
<td>B</td>
</tr>
<tr>
<td>General Exhaust (restrooms)</td>
<td>Galvanized</td>
<td>- 2&quot; w.g.</td>
<td>24</td>
<td>12</td>
<td>C</td>
</tr>
</tbody>
</table>
SECTION 233300 - HVAC DUCT ACCESSORIES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Backdraft dampers.
   2. Barometric relief dampers.
   4. Control dampers.
   5. Fire dampers.
   7. Combination fire and smoke dampers.
   8. Turning vanes.
   9. Duct-mounted access doors.
  10. Flexible connectors.
  11. Duct accessory hardware.

B. Related Requirements:
   1. Division 07 for Firestopping.
   2. Section 233100 "HVAC Metal Ducts" for flexible ducts.
   3. Division 26 for wiring connections.

1.3 ACTION SUBMITTALS

A. LEED Submittals:
   1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
   2. Product Data for Prerequisite EA 2: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
   1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
      a. Special fittings.
      c. Control-damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS


B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Provide duct accessories of materials suited to associated duct materials.

D. Air extractors shall not be used, except with the expressed written consent of the Design Engineer.

2.2 BACKDRAFT DAMPERS

A. General:

1. Provide manufacturer’s standard backdraft damper if available as fan or air-moving equipment accessory.

2. Provide damper material of the same material as associated ductwork.
B. Manufacturers:
2. Pottorff.
3. Ruskin Company.

C. Description: Gravity balanced.
3. Frame: 20 gage galvanized steel.
6. Blade Axles:
   a. Up to 42 inch damper width: Nonmetallic.
   b. 42 inch width and larger: Stainless steel.
7. Tie Bars and Brackets: Galvanized steel.

2.3 BAROMETRIC RELIEF DAMPERS

A. Description: Counterbalanced backdraft damper.
1. Sensitivity: 0.01 inch w.g. differential pressure.
2. Frame and blades: extruded aluminum.
5. Accessories:

2.4 MANUAL VOLUME DAMPERS

A. General Description: Factory fabricated, with required hardware and accessories.
B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
C. Damper material shall match associated ductwork.
D. Manufacturers:
1. Ruskin.
2. Louvers and Dampers.
E. Standard Manual Volume Dampers:
1. Standard leakage rating, with linkage outside airstream.
2. Suitable for horizontal or vertical applications.
4. Maximum System Pressure: 2 inch w.g.
2.5 CONTROL DAMPERS

A. Commercial Grade Control Dampers:

1. Manufacturers:
   a. Ruskin Company.
   b. Pottorff.
   c. Nailor.

2. Frames:
   a. 16 gage galvanized steel hat channel reinforced with corner braces.

3. Blades:
   a. Multiple blade with maximum blade width of 8 inches.
   b. Opposed-blade design.
   c. 14 gage Galvanized-steel airfoil.
   d. Blade Edging: neoprene, mechanically secured to blade.
   e. Stainless steel jamb seals.

4. Blade Axles: 1/2-inch-diameter; plated steel, operating temperature range from minus 25 to plus 250 deg F


7. Leakage Class 1. Testing according to AMCA Std. 500. Minimum ratings:
   a. System pressure: 3.5 inch w.g.
   b. System velocity: 3,000 FPM.

B. Low Leakage Industrial Grade Control Dampers:

1. Manufacturers:
   a. Ruskin Company.
   b. Pottorff.
   c. Nailor.

2. Frames: 12 gage galvanized steel channel.

3. Blades:
   a. Multiple blade with maximum blade width of 8 inches.
   b. Opposed-blade design.
   c. 16 gage Galvanized-steel airfoil.
   d. Blade Edging: EPDM, mechanically secured to blade.
   e. Stainless steel jamb seals.

4. Blade Axles: 1/2-inch-diameter; plated steel; blade-linkage hardware of stainless steel pivot pins with lock type retainers, with operating temperature range from minus 25 to plus 250 deg F.

5. Bearings:
   a. Stainless-steel pressed into frame.
   b. Thrust washers at each end of vertical mounted blades.


7. Leakage testing according to AMCA Std. 500. Minimum ratings:
   a. System pressure: 10 inch w.g.
   b. System velocity: 4,000 FPM.
2.6 FIRE AND SMOKE DAMPERS

A. Manufacturers:
1. Ruskin Company.
2. Louvers & Dampers, Inc.
3. Nailor Industries, Inc.

B. General Requirements:
1. Labeled according to UL 555C by an NRTL.
2. Fabricate in accordance with NFPA 90A.
3. Comply with construction details for tested assemblies as indicated in UL's "Fire Resistance Directory."
4. Fire Rating: to suit wall, floor, ceiling, or corridor assembly, refer to Architectural Drawings.
5. Operational ratings: suited to meet duct pressure and velocity design airflow conditions.

C. Fire Dampers:
1. Type: Dynamic.
2. Operational ratings: suited to meet design airflow conditions, and minimum 4-inch wg static pressure class and 2000-fpm velocity.
3. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, galvanized steel; with mitered and interlocking corners.
5. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

D. Smoke Dampers:
1. Smoke Detector: Integral, factory wired for single-point connection.
2. Operational ratings: suited to meet design airflow conditions, and minimum 4-inch wg static pressure class and 2000-fpm velocity.
4. Leakage: Class I.
5. Actuator: electric, out of airstream, two-position, fail closed.

E. Combination Fire and Smoke Dampers:
1. Operational ratings: suited to meet design airflow conditions, and minimum 4-inch wg (1 kPa) static pressure class and 2000-fpm (10 m/s) velocity.
4. Smoke Detector: Integral, factory wired for single-point connection.
6. Provide galvanized steel factory sleeve.
7. Actuator: electric, out of airstream, two-position, fail closed.
8. Leakage: Class I.

2.7 TURNING VANES

A. Manufacturers:
1. Duro Dyne Inc.
2. Ductmate Industries.
3. Metalaire.
4. Ruskin.

B. General Requirements: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

C. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
2. Double Wall: 2 inch inside radius. Vane length not to exceed 36 inch.

2.8 DUCT-MOUNTED ACCESS DOORS

1. Door:
   a. Double wall; insulation fill and thickness as indicated for duct pressure class, minimum 1 inch.
   b. Hinges and Latches: continuous piano hinge and cam latches.
   c. Shape and material to match ductwork.
   d. Fabricate doors airtight and suitable for duct pressure class.
   e. Doors shall open against air pressure.
   f. On access doors on ducts of 4 inch w.g. pressure or greater, provide sign reading "CAUTION – DOOR CLOSES WITH AIR PRESSURE".
2. Frame duct opening with continuous 1 inch by 1 inch angle. Provide sponge rubber or neoprene gasket at door-to-frame and frame-to-duct.

2.9 FLEXIBLE CONNECTORS

A. Manufacturers:
1. Durodyne.
2. Ventfabrics.

B. Materials: Flame-retardant or noncombustible fabrics. NFPA 90A compliant.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.
2.10 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless integral backdraft damper is provided, control damper is indicated, or otherwise indicated.

C. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel. Provide elevated dial or shaft extension for insulated ducts.

D. Install cable-driven remote volume dampers for all volume dampers located in inaccessible ceilings or as indicated on Contract Drawings.
   1. Locate wall box within 50 feet in accessible location.
   2. Wall box shall be recessed-type in finished spaces.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Fire Damper installation is required for all ductwork penetrating fire-rated walls, floors, and ceilings. Smoke damper installation is required for all ductwork penetrating smoke-rated partitions. Coordinate location and rating of fire and smoke dampers with Architectural Drawings. Provide dampers where required even if not shown on Mechanical Drawings.

I. Install fire and smoke dampers, with fusible links, according to manufacturer’s UL-approved written instructions.

J. Install turning vanes in all rectangular elbows.
   1. Ductwork of pressure class +/- 2-inch w.g. or lower: single wall vanes.
   2. Ductwork of pressure class +/- 3-inch w.g. and greater: double wall vanes.
   3. Acoustical turning vanes are not to be used unless specifically indicated on the Contract Drawings.

K. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot spacing.
8. Upstream or downstream from turning vanes.
9. Control devices requiring inspection.
10. Elsewhere as indicated.

L. Install access doors with swing against duct static pressure.

M. Access Door Sizes:
   1. Rectangular duct larger than 30 inches: 24 by 24 inches.
   2. Rectangular duct up to 30 inches: 16 by 20 inches.
   3. Rectangular duct up to 18 inches: 12 by 12 inches.
   4. For ducts smaller than 18 inches: 2 inch by 12 inch

N. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

O. Install duct test holes where required for testing and balancing purposes.

P. Install flexible connectors to connect ducts to air-moving equipment.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Operate dampers to verify full range of movement.
   2. Inspect locations of access doors and verify that purpose of access door can be performed.
   3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
   4. Inspect turning vanes for proper and secure installation.

END OF SECTION
SECTION 233400 - HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Centrifugal fans.

B. Related Requirements:
   1. Section 230513 - Common Motor Requirements for HVAC Equipment.
   2. Section 230548 - Vibration and Seismic Controls for HVAC Piping and Equipment.
   3. Section 233300 - Air Duct Accessories: Backdraft dampers.
   4. Division 26 - Equipment Wiring: Electrical characteristics and wiring connections.

1.2 REFERENCE STANDARDS

A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; American Bearing Manufacturers Association, Inc.; 1990 (Reapproved 2008).

B. ABMA STD 11 - Load Ratings and Fatigue Life for Roller Bearings; American Bearing Manufacturers Association, Inc.; 2014


D. AMCA 204 – Balance Quality and Vibration Levels for Fans.


H. NEMA MG 1 - Motors and Generators; National Electrical Manufacturers Association; 2011.

I. SMACNA (DCS) - HVAC Duct Construction Standards; 2005.

1.3 ACTION SUBMITTALS

A. See Division 01 - Administrative Requirements and Section 23 05 00 “HVAC and Plumbing General Requirements”, for submittal procedures.
B. Product Data: Provide data on centrifugal fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
   1. Fan operating efficiency.
   2. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   3. Material gages and finishes, including color charts.
   4. Dampers, including housings, linkages, and operators.

C. System Data: For systems with multiple fans in parallel, provide fan curves with fans noted in a single fan curve.

D. Shop Drawings: Indicate assembly of centrifugal fans and accessories including fan curves with specified operating point clearly plotted, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
   1. Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: Power, signal, and control wiring.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Structural supports.
   2. Roof openings.

1.5 CLOSEOUT SUBMITTALS

A. Submit under provisions of General Conditions and Division 01 as applicable.

B. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

C. Manufacturer’s Installation Instructions.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Maintenance Materials: Furnish the following for Owner’s use in maintenance of project.
   1. Extra Fan Belts: One set for each individual fan.
   2. Lubricant: One case of each type required.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum ten years of documented experience.
B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

D. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

E. UL Standards: Fans shall comply with UL 705.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect motors, shafts, and bearings from weather and construction dust.

1.9 FIELD CONDITIONS

A. Permanent fans may be used for ventilation during construction only after ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under observation.

B. Fans used during construction shall have all filters replaced when the Owner takes Ownership of the building.

C. Lift and support units with manufacturer's designated lifting or supporting points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Motors:
   1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   3. Speed Control: Fans shall be provided with Variable-frequency Drives (VFD) unless noted otherwise.
   4. Enclosure Type: Totally enclosed, fan cooled (TEFC) unless noted otherwise.

D. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal.
E. Static and Dynamic Balance: Eliminate vibration or noise transmission to occupied areas.

2.2 CENTRIFUGAL FANS (LAB EXHAUST FANS)

A. Manufacturers:
   1. Loren Cook Company.
   2. Greenheck.
   4. Twin City.

B. Description:
   1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
   2. Wheel shall be Airfoil, Backward Inclined, or Forward Curved.
   3. Fan shall be Single Width, Single Inlet (SWSI) or Double Width, Double Inlet (DWDI) as scheduled.

C. Construction:
   1. Heavy gage steel, spot welded, adequately braced, designed to minimize turbulence with tapered spun inlet bell and shaped cut. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, lifting lugs, and accessories.
   2. Fan wheel: Heavy backplate, hollow die-formed, blades continuously welded at tip flange and backplate, cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
   3. Factory finish before assembly to manufacturer's standard.
   4. Special Coating: Phenolic epoxy with UV protection.
   5. Fabrication: Conform to AMCA 99. Fan construction class shall be sufficient to meet fan design air flow and pressure; minimum fan class II.

D. Bearings and Drives:
   1. Bearings: Heavy duty pillow block type, selfgreasing ball bearings with ABMA 9 L10 life at 40,000 hours.
   2. Shafts: Hot rolled steel, ground and polished, with keyway, protectively coated with lubricating oil, and shaft guard. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
   3. Belt Drives:
      a. Factory mounted, with adjustable alignment and belt tensioning.
      b. Service Factor Based on Fan Motor Size: 1.5.
      c. Motor Pulleys: Adjustable pitch for use with motors through 5 HP; fixed pitch for use with motors larger than 5 HP. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
      d. Belt Guard: Fabricate to SMACNA Duct Construction Standards; 0.106 inch thick, 3/4 inch diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
E. Accessories:
   1. Backdraft Dampers: Gravity actuated with counterweight and interlocking blades with felt edges in steel frame installed on fan discharge.
   2. Access Doors: Shaped to conform to scroll, with quick opening latches and gaskets.
   5. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

2.3 ROOFTOP CENTRIFUGAL FANS (RESTROOM FANS)

A. Manufacturers:
   1. Loren Cook Company.
   2. Greenheck.
   3. Penn Barry.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; one-piece, aluminum base with venturi inlet cone.
   1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.

C. Fan Wheels: Aluminum hub and wheel.

D. Accessories:
   1. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
   2. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

E. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
   1. Configuration: Self-flashing without a cant strip, with mounting flange.
   2. Overall Height: 12 inches (300 mm).
   3. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
   4. Sound Curb: Curb with sound-absorbing insulation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install centrifugal fans level and plumb.

C. Install lab exhaust fans on structural bases, refer to 230548 “Vibration and Seismic Controls for HVAC Piping and Equipment”.

D. Curb Support: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," Low-Slope Membrane Roofing Construction Details.
Section, Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install and secure centrifugal fans on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.

E. Install fans with resilient electrical leads; refer to Division 26.

F. Provide sheaves required for final air balance.

G. Provide safety screen where inlet or outlet is exposed.

H. Provide backdraft dampers on discharge of exhaust fans and as indicated; refer to Section 233300 “Air Duct Accessories”.

I. Install units with clearances for service and maintenance.

J. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

K. Wrap lab exhaust fans in acoustical material as per the manufacturer’s recommendations, refer to 230713 “HVAC Duct Insulation” for material.

3.2 CONNECTIONS

A. Install flexible connections between fan inlet and discharge ductwork; refer to Section 233300 “Air Duct Accessories”. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.

B. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

C. Connect wiring according to Division 26.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. See Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
10. Remove and replace malfunctioning units and retest as specified above.
B. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION
SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Butterfly type constant and variable volume terminal units.
   2. Vortex-shedding type lab air valves

B. Related Sections:
   1. Section 233100—HVAC Metal Ducts
   2. Section 230548—Vibration and Seismic Controls for HVAC Piping and Equipment.
   3. Section 255005—Laboratory Monitoring and Control System

1.3 REFERENCE STANDARDS


B. ARI 880—Air Terminals.

C. ARI 885—Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   3. Provide sound power level data: include schedule of discharge and radiated sound power levels at rated capacity. Sound power levels shall be in the eight octave bands from 63 Hz to 8 kHz at design static pressure.

B. Shop Drawings: For air terminal units.
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Size and location of initial access modules for acoustic tile.
   3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Division 01:
      a. Instructions for resetting minimum and maximum air volumes.
      b. Instructions for adjusting software set points.

1.7 QUALITY ASSURANCE

A. Test and rate air performance for air pressure drop, flow performance, and acoustical performance in accordance with ARI 880 and ARI 885. Attach ARI seal to each terminal unit.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 – “Systems and Equipment” and Section 7 – “Construction and System Start-up.”

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, “Section 6 – Heating, Ventilating, and Air Conditioning.”

D. Control devices shall be provided and factory-installed by Division 25.

2.2 BUTTERFLY TYPE TERMINAL UNITS

A. Manufacturers:
   1. Price Industries.
   2. Nailor Industries Inc.
   3. Titus.

B. Casing: Galvanized steel, single wall.
1. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
2. Air Outlet: S-slip and drive connections.
3. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Damper shall be capable of full shut off (zero air volume).
   2. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.

D. Casing Liner: Fiber-Free Foam Insulation.
   2. Insulation shall comply with UL 181 erosion, mold growth and humidity requirements in accordance with ASHRAE 62.1.
   3. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

E. Airflow Sensor shall be a crossflow, differential pressure airflow device measuring total and static pressures, and mounted to the inlet valve.
   1. Sensor signal accuracy shall be plus or minus five percent throughout terminal operating range.

2.3 LAB AIR VALVES

A. Manufacturers:
   1. Accutrol Accuvalve
   2. Or Equal.

B. Casings:
   1. Valve body material for Fume Hood, Exhaust or other corrosive service shall be 304SS; 20gauge for body and 16gauge for blades. Valve shaft material shall be 316SS. Coated valves are not acceptable.
   2. Valve body material for non-corrosive service such as for Supply shall be 16 gauge aluminum for body and 16 gauge for blades. Valve shaft material shall be 316SS.

C. Construction:
   1. A compression section, two airflow control surfaces, factory-mounted digital vortex airflow measuring device factory-mounted high speed electric actuator, integral access panel and integrated high performance closed-loop feedback controller with native BACnet.
   2. The compression section shall divide the airstream into at least two separate airstreams. Each airstream shall be approximately equal in size and the total open area shall be approximately 50% of the duct open area. The divided sections shall cause compression therefore creating a more laminar flow for better airflow measurement and turndown. The compression section shall be of an aerodynamic shape with a static regain section to insure minimal pressure drop. The valve shall not require any duct straight runs either upstream or downstream of the airflow valve to achieve required specified performance.
   3. The airflow control valve shall be capable of being mounted in any position (360º mounting plane) in ductwork without the need for recalibration. It shall not be required to specify mounting plane when ordering valve.
D. Airflow Sensor
   1. Digital vortex type airflow sensing device.

E. Accuracy & Response Time:
   1. Airflow control valves shall be a linear type and shall operate with a minimum turndown ratio of 8 to 1.
   2. The airflow control valve speed of response shall be <1 second.

F. Pressure Drop
   1. Airflow control valves shall be of a low pressure drop design for energy efficiency. Valves shall not require greater pressure drop than listed at Max CFM on project valve schedule or 0.3" wc, whichever is less.

G. Operation:
   1. The air valve shall be pressure independent over a 0.05" to 3.0" W.C. drop across the valve. Integral pressure independent assembly shall respond and maintain specific air flow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of air flow controllers on a manifold system.
   2. Air flow accuracy shall be plus or minus 5% of reading or 5 CFM, whichever is greater, over an air flow turndown range of no less than 8 to 1.
   3. Electronic low-voltage actuator shall be factory mounted to the valve. Loss of electric power shall cause exhaust valves to fail open to the maximum scheduled design flow and supply valves to fail to the minimum scheduled air flow.
   4. Certification: Each air valve shall be factory calibrated to the project specific air flows as indicated on the contract drawings using air stations and instrumentation having a combined accuracy of at least plus or minus 1% of signal over the entire range of measurement. All air valves shall be marked with valve specific data; at a minimum they shall be marked with valve tag number, serial number, model number, quality control inspection number, and design air flow.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA’s “HVAC Duct Construction Standards – Metal and Flexible,” Ch. 5, “Hangers and Supports” and with Section 230529 “Hangers and Supports for HVAC Piping and Equipment.”

B. Building Attachments: Concrete inserts or structural-steel fasteners appropriate for construction materials to which hangers are being attached. Where practical, install concrete inserts before placing concrete.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
3.2 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with ASCE/SEI 7. Comply with requirements for seismic-restraint devices in Section 230548 “Vibration and Seismic Controls for HVAC.”

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on air terminal units that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:
   1. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Set anchors to manufacturer’s recommended torque, using a torque wrench.
   5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.3 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems.”

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.4 CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Comply with requirements in Section 233113 “Metal Ducts” for connecting ducts to air terminal units.
3.5 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 “Identification for HVAC Piping and Equipment” for equipment labels.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
   2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. Train Owner’s maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION
SECTION 233700 - AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 SECTION INCLUDES
   A. Perforated diffusers.
   B. Adjustable blade face registers.
   C. Fixed face grilles.
   D. Linear slot diffusers.
   E. Laminar flow diffusers.

1.2 REFERENCE STANDARDS

1.3 SUBMITTALS
   A. See Division 01 – Administrative Requirements for submittal procedures.
   B. Product Data: Provide data for equipment required for this project, including materials of construction, finish, accessories furnished and mounting details. Provide performance data including throw and drop, static-pressure drop, and noise ratings. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, color, and noise level.
   C. Project Record Documents: Record actual locations of air outlets and inlets.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS
   A. MANUFACTURERS
      1. Titus.
      2. Price Industries.
      3. Or equal.
   B. Air outlets associated with variable air volume systems shall be specifically designed for variable air volume flows.
C. Material: Unless noted otherwise: Aluminum.

D. Finish: Unless noted otherwise: Baked enamel, color selected by Architect.

E. Mounting: compatible with surface construction, refer to Architectural drawings. Use countersunk screws when applicable unless noted otherwise.

F. Integral dampers shall not be permitted unless noted otherwise.

G. Provide extended neck when connecting to flexible duct.

2.2 SUPPLY PERFORATED DIFFUSERS (A)

A. Material: Aluminum or steel backpan and curved blade pattern controllers, with aluminum face.

B. Face Style: Extended, removeable.

C. Pattern Controller: Adjustable with pattern controllers.

D. Accessories:
   1. Equalizing grid.
   2. Backpan insulation.

2.3 LAMINAR FLOW DIFFUSERS (B)

A. Airflow Principle: Laminar flow.

B. Face Style: Radial, removeable, with retainer cables.

C. Accessories:
   1. Equalization baffle.
   2. Backpan insulation.

2.4 LINEAR SLOT DIFFUSERS (C)

A. Airflow Principle: Supply.

B. Finishes: Powder coat, color selected by architect.

C. Plenum: Insulated, fiber free.

D. Other Features:
   1. Blank-off strips, as required.

2.5 RETURN/EXHAUST/TRANSFER PERFORATED DIFFUSERS (D)

A. Material: Aluminum or steel backpan, with aluminum face.
B. Face Style: Flush.

2.6 SPIRAL ADJUSTABLE BLADE FACE REGISTERS (E)
   A. Suitable for mounting on round ductwork.
   B. Material: Steel.
   C. Face Blade Arrangement: Horizontal; spaced 3/4 inch apart.
   D. Rear Blade Arrangement: Vertical; spaced 3/4 inch apart.

2.7 ADJUSTABLE BLADE FACE REGISTERS (F)
   A. Material: Steel.
   B. Face Blade Arrangement: Horizontal; spaced 3/4 inch apart.
   C. Rear Blade Arrangement: Vertical; spaced 3/4 inch apart.

2.8 FIXED FACE GRILLES (G)
   A. Material: Steel.
   B. Face Blade Arrangement: Horizontal; spaced 1/2 inch apart.
   C. Blade deflection: 35 degrees.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Install in accordance with manufacturer’s instructions.
   B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
   C. Install diffusers to ductwork with air tight connection.
   D. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
   E. Paint ductwork visible behind air outlets and inlets matte black. Refer to Division 09.
   F. Install diffusers, registers, and grilles level and plumb.
   G. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final
locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

H. Install diffusers, registers, and grilles to ducts to allow service and maintenance of dampers, air extractors, and fire dampers.

I. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

J. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

K. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

END OF SECTION
SECTION 237300 – CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes:
   1. Custom outdoor supply air handling units.
   2. Custom outdoor exhaust air energy recovery units.

B. Related sections:
   1. Section 230513 - Common Motor Requirements for HVAC Equipment.
   2. Section 230548 - Vibration and Seismic Controls for HVAC Piping and Equipment.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings:
   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Prepare the following by or under the supervision of a qualified professional engineer:
      a. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof-curb mounting details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Size and location of unit-mounted rails and anchor points and methods for anchoring units to roof curb.
   2. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.

B. Seismic Qualification Certificates: For dedicated outdoor-air units, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Startup service reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fan Belts: One set for each belt-driven fan.
   2. Filters: One of each type for each unit.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 12 months from date of Substantial Completion or 18 months from shipment, whichever period expires first.

B. Unit casing and structural base shall be warrantied (parts and labor) against corrosion or failure under normal operating conditions for a period of 40 years from the date of unit delivery.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Air Enterprises
B. Energy Labs.
C. Haakon.
D. Huntair.
E. Trane.
2.2 PERFORMANCE REQUIREMENTS

A. Design unit and ancillary equipment for outdoor installation.

B. General Fabrication Requirements: Comply with requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."

C. Seismic Performance: Units shall withstand the effects of earthquake motions determined according to ASCE 7-10.
   1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."
   2. Equipment anchorage is not a deferred submittal nor a delegated design item. Refer to details on the drawings for anchorage requirements.

D. Cabinet Thermal Performance:
   1. Maximum Overall U-Value: Comply with requirements in ASHRAE/IESNA 90.1.
   2. Include effects of metal-to-metal contact and thermal bridges in the calculations.

E. Cabinet Surface Condensation:
   1. Cabinet shall have additional insulation and vapor seals if required to prevent condensation on the interior and exterior of the cabinet.
   2. Portions of cabinet located downstream from the cooling coil shall have a thermal break at each thermal bridge between the exterior and interior casing to prevent condensation from occurring on the interior and exterior surfaces. The thermal break shall not compromise the structural integrity of the cabinet.

F. Maximum Cabinet Leakage: 1 percent of the total supply-air flow at a pressure rating equal to the fan shut-off pressure.

G. Cabinet Deflection Performance:
   1. Walls and roof deflection shall be within 1/200 of the span at the design working pressure equal to the fan shut-off pressure. Deflection limits shall be measured at any point on the surface.
   2. Floor deflections shall be within 1/300 of the span considering the worst-case condition caused by the following:
      a. Service personnel.
      b. Internal components.
      c. Design working pressure defined for the walls and roof.

H. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 CABINET AND BASE

A. Construction: Double wall.

B. Casing Material: Aluminum.

D. Base: All-aluminum or stainless steel structural base. The base shall be designed to distribute loads properly to a suitable mounting surface and be braced to support internal components without sagging, pulsating or oil canning.
   1. Perimeter support members shall be a minimum of 6" structural member properly sized to support all major components and the housing during rigging, handling and operation of the unit.

   1. Service Doors: Hinged access doors with gaskets. Material and construction of doors shall match material and construction of cabinet in which doors are installed.

F. Roof: Standing seam or membrane; sloped to drain water.

G. Floor: Reinforced, metal surface. The base floor shall be designed for a minimum live load of 100 pounds per square foot throughout the unit. Insulation shall be below metal walking surface.

H. Cabinet Insulation:
   1. Type: Fibrous-glass duct lining complying with ASTM C 1071, Type II.
   2. Weight: 3 pcf.
   3. Thickness: 2 inches.
   5. Mechanical Fasteners: Suitable for adhesive, mechanical, or welding attachment to casing without damaging liner and without causing air leakage when applied as recommended by manufacturer.

I. Condensate Drain Pans:
   1. Shape: Rectangular, with slope in at least two planes to direct water toward drain connection.
   2. Size: Large enough to collect condensate from cooling coils including coil piping connections, coil headers, and return bends.
      a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
      b. Depth: A minimum of 2 inches deep.
   3. Configuration: Double wall, with space between walls filled with foam insulation and moisture-tight seal.
   5. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

J. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1 for resistance to mold and erosion.

K. Each section of the unit base shall contain a minimum 1” NPT drain to facilitate system washdown, maintenance and condensate removal. Clean out drains shall be provided with removable caps of non-corrosive material.

L. All unit base service openings shall be framed with a minimum 2” high water dam continuously welded to the floor. All pipe and electric conduit chases with openings to building or elements shall be covered with thin gage aluminum or 304 stainless steel.
M. Pipe and conduit penetrations through the unit casings shall be provided by the unit manufacturer and be properly sealed prior to leaving the factory. Penetrations sealed by simply caulking around extension are not acceptable.

2.4 SUPPLY FAN

A. Plenum Fan Type: Single width, non-overloading, with backward-inclined or airfoil blades.
   1. Fan Wheel Material: Aluminum; attached directly to motor shaft.
   5. Fan Balance: Precision balance fan below 0.08 inch/s at design speed with filter in.
   6. Backdraft Damper per fan.

B. Service Factor for Belt Drive Applications: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly with minimum 1.5 service factor.

C. Motors:
   1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   2. Totally enclosed fan cooled.
   4. Mount on an adjustable slide rail motor base with two adjusting bolts per side. The fan motors shall be factory wired to an external junction box with flexible conduit of adequate length so that it will not have any affect on the vibration isolation.

D. Mounting: Fan wheel, motor, and drives shall be mounted to fan casing with spring isolators. Refer to Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

E. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.

2.5 COILS

A. Capacity Ratings: Comply with ASHRAE 33 and ARI 410 and coil bearing the ARI label.

B. Construction:
   2. Tube Material: Copper.
   3. Tube Header Material: Copper or prime coated steel with brazed joints.
   4. Fin Material: Aluminum.
   5. Fin and Tube Joints: Mechanical bond.
   6. Reinforcing shall be furnished so that the unsupported length is not over 60”.

C. Leak Test: Coils shall be leak tested with air underwater at 300 psi and rated for 150-psi working pressure.

D. Drainable, with threaded plugs for drain and vent; threaded plugs in return bends and in headers opposite each tube.
E. All sides of coils shall be carefully blanked off to ensure all air passes through the coil.

2.6 OUTDOOR-AIR INTAKE LOUVER

A. Type: Acoustic louver.
B. Materials: Aluminum.
C. Bird Screen: Comply with requirements in ASHRAE 62.1.
D. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.7 Sound Transmission Loss:

<table>
<thead>
<tr>
<th>Frequency, Hz</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum dB</td>
<td>9</td>
<td>11</td>
<td>13</td>
<td>15</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>18</td>
</tr>
</tbody>
</table>

A. Basis of Design: Kinetics Noise Control KCal-1, 6” thick.

2.8 FILTERS

A. Provide filter-holding frames to accommodate scheduled filters.
B. Mounting Frames:
   1. Panel filters arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or from access plenum.
   2. Extended surface filters arranged for flat orientation, removable from access plenum.
   3. Aluminium or stainless steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.
C. Factory install at each filter bank a Dwyer Magnehelic “Series 2000” pressure gauge complete with static pressure tips, hardware and fittings. Enclose the gauge in a protective sheet metal box with a hinged inspection door. Paint to match unit.

2.9 ELECTRICAL POWER CONNECTIONS

A. General Electrical Power Connection Requirements: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices shall provide a single-point field power connection to unit.
B. Enclosure: NEMA 250, Type 4X, mounted in unit with hinged access door in unit cabinet having a lock and key or padlock and key,
C. Wiring: Numbered and color-coded to match wiring diagram.
D. Wiring Location: Install factory wiring outside an enclosure in a raceway.
E. Factory Wiring: Branch power circuit to each motor and to controls with one of the following disconnecting means:
1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
2. NEMA KS 1, heavy-duty, nonfusible switch.
3. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

F. Factory-Mounted, Overcurrent-Protection Service: For each motor.

G. Controls: Factory wire unit-mounted controls where indicated.

H. Lights: Factory wire unit-mounted lights.

I. Receptacle: Factory wire unit-mounted, ground fault interrupt (GFI) duplex receptacle.

J. Control Relays: Auxiliary and adjustable time-delay relays.

2.10 CONTROLS

A. Control equipment and sequence of operation are specified in Division 25.

B. Control Wiring: Factory wire connection for controls' power supply.

C. Control Devices: Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves shall be manufacturer's standard items to accomplish indicated control functions.

D. Control Dampers:
   1. Damper Location: Factory installed inside unit for ease of blade axle and bushing service. Arrange dampers located in a mixing box to achieve convergent airflow to minimize stratification.
   2. Damper Leakage: Comply with requirements in AMCA 500-D. Leakage shall not exceed 6.5 cfm per sq. ft. at a static-pressure differential of 4.0 inches water column when a torque of 5 inch pounds per sq. ft. is applied to the damper jackshaft.
   3. Damper Rating: Rated for close-off pressure equal to the fan shutoff pressure.
   4. Damper Label: Bear the AMCA seal for both air leakage and performance.

E. Integral Smoke Alarm: Smoke detector installed in supply air.

2.11 ACCESSORIES

A. Service Lights and Switch: Factory installed in each accessible section with weatherproof cover. Factory wire lights to a single-point field connection.

B. Duplex Receptacle: Factory mounted in unit supply-fan section, with 20 amp 120 V GFI duplex receptacle and weatherproof cover.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's rigging and installation instructions for unloading units and moving to final locations.

B. Curb Support: Install roof curb on roof structure according to "The NRCA Roofing Manual."
   1. Install and secure units on curbs and coordinate roof penetrations and flashing with roof construction.
   2. Coordinate size, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
   3. Coordinate size, location, and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.

C. Restrained Curb Support: Install restrained vibration isolation roof-curb rails on roof structure according to "The NRCA Roofing Manual."

D. Equipment Mounting:
   1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

E. Install separate devices furnished by manufacturer and not factory installed.

F. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

G. Install drain pipes from unit drain pans to sanitary drain.

3.3 CONNECTIONS

A. Where installing piping adjacent to units, allow space for service and maintenance.

B. Hydronic Piping Connections:
   1. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties."
   2. Install shutoff valve and union or flange on each supply connection and install balancing valve and union or flange on each return connection.
C. Duct Connections:
   1. Comply with requirements in Section 233113 "Metal Ducts."
   2. Drawings indicate the general arrangement of ducts.
   3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

D. Electrical Connections: Comply with requirements for power wiring, switches, and motor controls in electrical Sections.
   1. Install electrical devices furnished by unit manufacturer but not factory mounted.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Inspect casing insulation for integrity, moisture content, and adhesion.
   3. Verify that clearances have been provided for servicing.
   4. Verify that controls are connected and operable.
   5. Verify that filters are installed.
   6. Clean coils and inspect for construction debris.
   7. Inspect and adjust vibration isolators and seismic restraints.
   8. Verify bearing lubrication.
   9. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
   10. Adjust fan belts to proper alignment and tension.
   11. Start unit.
   12. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
   13. Operate unit for run-in period.
   15. Adjust and inspect high-temperature limits.
   16. Verify operational sequence of controls.
   17. Measure and record airflows. Plot fan volumes on fan curve.

B. After startup, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace components that do not properly operate and repeat startup procedures as specified above.

D. Prepare written report of the results of startup services.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units; minimum 4 hours.

END OF SECTION
SECTION 238143 - AIR-SOURCE HEAT PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes unitary heat pumps with refrigerant-to-water heat exchangers, refrigeration circuits, air-to-refrigerant heat exchanger and refrigerant compressor(s).
B. Related Sections:
   1. Section 230000 Section "HVAC General Requirements".
   2. Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment".
   3. Section 230593 "Testing, Adjusting, and Balancing for HVAC".

1.3 ACTION SUBMITTALS
A. Submit under provisions of Section 230000" HVAC General Requirements" and Division 01.
B. Product Data:
   1. Manufacturer’s literature on heat pumps and required accessories.
   2. Certified equipment capacity and efficiency performance at full and part load conditions. Correct ratings for temperature and altitude where applicable.
   3. Sound power levels at rated capacity.
   4. Material thickness and finishes, including color charts.
   5. Any dampers, including housings, linkages, and operators.
   6. Refrigerant capacity.
   7. Construction details.
   8. Dimensions, shipping weight, and operating weight.
   10. Coil data sheets.
C. Operation and Maintenance Data: Submit O&M manual immediately after the heat pump’s production order has been placed. The O&M manual shall include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams. The O&M manual shall only be provided for the specific model, serial number and location of the specific unit installed for the project. The actual heat pump sheet including the actual tested voltage, amperages, measured flow and LBNL equipment ID shall be updated and included in the O&M manual. Generic fan data sheet, O&M manual is not acceptable.
D. Shop Drawings:
   1. Include plans, elevations, sections, and mounting, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For air-source unitary heat pumps, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each type of air-source unitary heat pump, signed by product manufacturer.

C. Field quality-control reports.

D. Sample Warranty: For manufacturer's warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-source unitary heat pumps to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of air-source unitary heat pumps that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, refrigeration components.
   2. Warranty Period: Five years from date of Substantial Completion.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver to site, store, and protect products under provisions of Section 230000 "General Requirements for HVAC", Material Delivery and Storage.

B. Ship each unit with a full charge of refrigerant. Charge each unit with nitrogen if refrigerant is shipped in containers separate from unit.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Units shall withstand the effects of earthquake motions determined according to ASCE 7-10.

B. Comply with ASHRAE 15.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with safety requirements in UL 484 for assembly of free-delivery, air-source heat pumps.

E. Comply with all performance parameters stated on the drawing schedule. Heat pump unit must meet or exceed efficiency parameters to be considered as a potential substitution.

2.2 AIR-SOURCE HEAT PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Aermec
   2. Climacool

B. Description: Packaged air-source heat pump with temperature controls and integral primary pump(s); factory assembled, piped, wired, tested, and rated according to ASHRAE/ARI/ISO-13256-1.
   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Heat pump shall be capable of operating in heat recovery (4-pipe) if required, see schedules. All heat pumps shall be capable of operating in heating and cooling only modes (2-pipe).
   1. In heat recovery operation, the system shall be capable of modulating the percentage of water-to-water recovery and air-to-water heat transfer, providing a 0 to 100 percent range of recovery.

D. Direct-driven blower with EC motor.
   1. Provide economizer capable of up to 100% economizer.

E. Filter: 2 inch thick mini-pleat. MERV 16 per ASHRAE std 52.2.

F. Cabinet and Chassis:
   1. Access panel for access and maintenance of internal components.
   2. Knockouts for electrical connections.
   3. Minimum 20 gage panels degreased and coated with electrostatically applied baked-on polyester powder paint appropriate for coastal salty climate.

G. Refrigerant Circuit Components:

2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
4. Minimum two independent refrigerant circuits with single or multiple compressors in tandem per circuit for optimal staging and load control. Single circuited units will not be accepted.
5. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
6. Compressor:
   a. Scroll
   b. Two stage or Variable speed.
   c. Installed on vibration isolators and mounted on a structural steel base plate and full-length channel stiffeners.
   d. Exterior of compressor shall be wrapped with a high-density sound-attenuating blanket and housed in an acoustically treated enclosure.
   e. Crankcase heater.
   f. Factory-Installed Safeties:
      1) Antirecycle timer.
      2) High-pressure cutout.
      3) Low-pressure cutout or loss of charge switch.
      4) Internal thermal-overload protection.
7. Evaporator and condenser:
   a. Brazed Plate, type 316 stainless-steel construction. Externally insulated with closed cell material to reduce thermal dispersions.
   b. Heater: Factory-installed and wired electric heater with integral controls designed to protect the evaporator.
   c. Inlet strainer and flow switch.
8. Air-Side Coil Exchanger:
   1) Coils shall be constructed from seamless copper tubes mechanically expanded into aluminum fins and shall have integral subcooling circuits.
   2) Condenser fans shall be axial type, aerodynamically designed for ultra-low noise level generation.
   3) Fan Motors shall be inverter allowing fan speed modulation from a 0-10V signal. Motors shall be weather protected, three-phase, with permanently lubricated ball bearings. Motors safeties shall include magnetic circuit breakers. On/off motors will not be accepted.
   4) Fan Guards: Steel safety guards with corrosion-resistant coating.
   5) Unit shall be able to modulate the fan speed based on high pressure when in cooling mode, and based on low pressure when in heating mode.
10. Pipe Insulation: Refrigerant minimum 3/8-inch-thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes according to ASTM E 84.
11. Pipe Insulation Cladding: All exterior insulation shall be clad with aluminum or stainless steel per Section 230719 and/or Section 230716.
12. Identify insulated piping and unit per Section 230553; All piping must be labeled and direction of flow indicated.

H. Pumps:
1. Integrated pumping modules for Chilled Water and Heating Hot Water systems.
2. See Section 232123 for pump specifications.

I. Controls:
1. Unit shall be equipped with a standalone microprocessor-based control system. The control logic shall be designed to maximize operating efficiency and equipment life with protections for operation under unusual conditions. The system shall intelligently stage the unit to sustain leaving water temperature precision and stability while minimizing compressor cycling.
2. Basic Unit Control Modes and Devices:
   a. Economizer operation.
   b. Occupancy-based shutdown.
   c. Unit shutdown on high or low refrigerant pressures.
   d. Unit shutdown on low water temperature.
   e. Low- and high-voltage protection.
   f. Overcurrent protection for compressor.
   g. Random time delay, three to 10 seconds, start on power-up.
   h. Time delay override for servicing.
   i. Control voltage transformer.
   j. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
   k. Ability to defeat time delays for servicing.
   l. Digital display to indicate high pressure, low pressure, low voltage, and high voltage.
   m. The low-pressure switch shall not be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
   n. Remote fault-type indication at thermostat.
   o. Selectable 24-V dc or pilot duty dry contact alarm output.
   p. Service test mode for troubleshooting and service.
   q. Unit-performance sentinel warns when heat pump is running inefficiently.
   r. Compressor soft start.
3. DDC interface requirements as further described in Section 230923 "Direct Digital Control (DDC) System for HVAC".
   a. Interface relay for scheduled operation.
   b. Interface relay to provide indication of fault at central workstation.
   c. Provide BAC-net interface for central DDC workstation for the following functions:
      1) Set-point adjustment.
      2) Start/stop and operating status of heat-pump unit.
      3) Data inquiry to include supply-air and room-air temperature and humidity, and entering-water temperature.
      4) Occupied and unoccupied schedules.

J. Electrical Connection: Single electrical connection with fused disconnect meeting all requirements defined in Section 26. System must be provided with a dedicated Lock Out Tag Out device with an O&M Manual describing the Lock Out Tag Out procedure for this specific piece of equipment.
2.3 ACCESSORIES

A. Loop Controller.

B. Condensate Pump Module:
   1. Minimum 1/2 HP, 230-V, single-phase pump, rated for at least 3 gpm per 12,000 Btu/hr capacity at 20 feet of head.
   2. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   3. Include pump module hose kit with thread to barb fittings, hose, and hose clamps.
   5. Include controls to operate pump as required to maintain room temperature and ventilation set points.

C. Outdoor louvers, aluminum with birdscreen.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for electric installations for heat pumps to verify actual locations connections and electrical conduits before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

D. Meet requirements of Division 01 “Demonstration and Training” and Commissioning.
   1. Provide support including false loading equipment for Commissioning function test to verify units’ supplemental heat for morning warm up / low temperature operation is functional.

E. Subcontractor shall provide 48 hours advance notice of all inspections to the University Representative to witness inspection. Hold for inspection or witness.

3.2 INSTALLATION

A. Equipment Mounting:
   1. Comply with requirements for vibration-isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 CONNECTIONS

A. Drawings indicate general arrangement of ductwork, fittings, and specialties. Specific connection requirements are as follows:

B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.
3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following field tests and inspections:
   1. After installing heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Heat pumps will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Inspect for visible damage to unit casing.
   3. Inspect for visible damage to compressor and coils.
   4. Inspect internal insulation.
   5. Verify that labels are clearly visible.
   6. Verify that clearances have been provided for servicing.
   7. Verify that controls are connected and operable.
   8. Adjust vibration isolators.
   9. Start unit according to manufacturer's written instructions.
   10. Complete startup sheets and attach copy with Contractor's startup report.
   11. Inspect and record performance of interlocks and protective devices; verify sequences.
   12. Operate unit for an initial period as recommended or required by manufacturer.
   13. Verify thermostat calibration.
   14. Inspect controls for correct sequencing of heating, refrigeration, and normal and emergency shutdown.

3.6 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to four visits to Project during other-than-normal occupancy hours for this purpose.
   1. Factory representative must participate in the Commissioning process. A minimum of two of these visits shall be dedicated to supporting functional testing of the equipment in the Commissioning process.
3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-source unitary heat pumps; minimum 4 hours.

END OF SECTION
SECTION 238219 - FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Ducted fan coil units and accessories.

B. Related Requirements:
   1. Section 232113 "Hydronic Piping".
   2. Section 233100 "HVAC Metal Ducts".

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Submit under provisions of General Conditions and Division 01 as applicable.

B. Shop Drawings:
   1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly construction details, components electrical characteristics, and connection requirements.
   2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which fan coil units will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustic tile.

B. Seismic Qualification Certificates: For fan coil units, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Submit under provisions of General Conditions and Division 01 as applicable.

B. Operation and Maintenance Data: Include operation and maintenance manual. Include instructions for lubrication, motor, drive replacement, and spare parts list and wiring diagram.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: Furnish one set of extra filters for each filter type installed.

1.7 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.8 COORDINATION

A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of louvers and wall sleeves for outdoor-air intake where applied.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Fan failure.
   b. Coil leak.

2. Warranty Period: Five years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Manufacturers:
   1. International Environmental Coil.
   2. Daikin.
   3. Carrier.
   4. Trane.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 FAN COIL UNITS

A. Coil Section Insulation: 1-inch-thick, coated or foil-faced glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
   1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
   2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Main and Auxiliary Drain Pans: Stainless steel or insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1.

C. Chassis: Galvanized steel where exposed to moisture, with powder-coat finish and removable access panel. Floor-mounting units shall have leveling screws.

D. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
   1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis.
   2. Return-Air or Mixing Plenum: Sheet metal plenum finished to match the chassis.
   3. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.

E. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
   1. 1” Pleated type.

F. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

G. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
1. Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

H. Basic Unit Controls:
   1. Control voltage transformer.
   2. Unit-mounting thermostat with the following features.
      b. Fan on-auto switch.
      c. Fan-speed switch.
      d. Automatic changeover.
      e. Adjustable deadband.
   3. Wall-mounting temperature sensor.
   4. Unoccupied-period-override push button.
   5. Data entry and access port.
      a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
      b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

I. DDC Terminal Controller:
   1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
   2. Controller shall have volatile-memory backup.

J. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fan coil units level and plumb.

B. Install fan coil units to comply with NFPA 90A.

C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
D. Verify locations of thermostats and other exposed control sensors with Drawings and room details before installation.

E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   1. Install piping adjacent to machine to allow service and maintenance.
   2. Connect condensate drain to indirect waste.
      a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Division 26.

D. Connect wiring according to Division 26.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

END OF SECTION
SECTION 250000 – BUILDING AUTOMATION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install a digital Building Automation System (BAS) as specified herein.

1.2 COORDINATION WITH OTHER TRADES

A. Consult all other Sections, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable installation. This section is provided to assist Contractor in coordination of work scope but shall not be construed to limit Contractor’s scope of work encompassed by the contract documents.

B. The following table is intended to assist the Contractors in coordinating the scope of work between Division 25 Building Automation System (indicated as 25), and other Divisions as indicated. However, the General Contractor is ultimately responsible for coordination among his subcontractors regardless of what is listed in this Section.

<table>
<thead>
<tr>
<th>System</th>
<th>Division under which the following is specified</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equipment</td>
<td>Installation</td>
</tr>
<tr>
<td>Fire &amp; Life safety Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire alarm controls</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Duct mounted &amp; in-duct mounted smoke detectors</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>Other smoke detectors</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Smoke control interlocks to HVAC fans</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Smoke dampers with electric actuators</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Smoke damper end switches</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Mechanical Equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unitary mechanical equipment</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>ASHP</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Variable speed drives, field mounted</td>
<td>23</td>
<td>26</td>
</tr>
<tr>
<td>Motors, 3 phase</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Motor starters, 3 phase</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Motors, 1 phase</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Disconnects/circuit breakers</td>
<td>26/2 3</td>
<td>26/2 3</td>
</tr>
<tr>
<td>Building Automation System (BAS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central control workstations &amp; servers</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Contra Costa Community College District
Contra Costa College
C-4016 New Science Building – DSA Backcheck
## INTERFACE / RESPONSIBILITY MATRIX

<table>
<thead>
<tr>
<th>System</th>
<th>Division under which the following is specified</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equipment</td>
<td>Installation</td>
</tr>
<tr>
<td>Control system network backbone</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Line voltage control devices to 120V motors</td>
<td>25</td>
<td>26</td>
</tr>
<tr>
<td>Window switches</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Control panels</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Control devices</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td><strong>ELECTRICAL Systems</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lighting Control BACnet gateway</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Lighting relay panels and low voltage switches</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Lighting occupancy sensors</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Daylighting sensors and controls</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Power monitoring sensors and gateway</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td><strong>Plumbing Systems</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas and water flow meters</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td>Recirculation pumps or heat tape</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Pipe gauges, thermometers, test plugs</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Self-powered valves, pressure relief valves, liquid level controllers, etc.</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Sensor wells, meters and other pipe-mounted control devices</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td><strong>HVAC Hydronic Systems</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe gauges, thermometers, test plugs</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Self-powered valves, refrigerant powered head pressure control valves, pressure relief valves, liquid level controllers, etc.</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Automatic isolation and control valves</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>Sensor wells, meters and other pipe-mounted control devices</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td><strong>HVAC Sheet metal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duct mounted sensors</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>Control dampers</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Control damper actuators</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td><strong>Packaged VAV air conditioning Systems</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC unit including all controls</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td><strong>Laboratory HVAC Systems</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory air valves, actuators, and controllers</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Fume hoods</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Snorkels with manual dampers</td>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>Snorkels with control dampers</td>
<td>11/23</td>
<td>23</td>
</tr>
<tr>
<td>Fume hood ASHRAE 110 tests</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>System</td>
<td>Equipment</td>
<td>Installation</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-----------</td>
<td>--------------</td>
</tr>
<tr>
<td>Fume hood sash closer and associated sensors</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Fume hood monitors</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Fume hood sash position sensors</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>HVAC Terminal Boxes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terminal box control transformer panel</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Terminal box with damper</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Digital controller and damper actuator</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Air-flow measurement pickup</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Air-flow measurement transducer and piping</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Wall sensor module</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Terminal fan</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Electric reheat coil, including control transformer, safeties &amp; contactors</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>HW control valve and actuator</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>miscellaneous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceiling and wall access doors and panels</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

NUMBERED REMARKS:
Wiring includes raceway, fittings, wire, boxes and related items, all voltages.
Wiring and controls to start and stop fans based on smoke detector status and smoke control logic specified under Division 26 Electrical.
Factory installed starters and variable speed drives are specified under Division 23 HVAC. Prewired control panel is specified under Division 23 HVAC; single point power connection (unless otherwise noted on drawings) specified by Division 23 HVAC.
Applies to motors that are not covered by note 0. Integral starter control devices such as HOA switches, 120V control transformers specified under Division 26 Electrical.
Single phase 120V motors with integral motor overload protection specified under Division 23 HVAC.
Line voltage control device such as thermostat or switch specified under Division 25 BAS; wiring and conduit between control device and motor specified under Division 26 Electrical.
Factory installed and wired chilled and condenser water flow switches are specified under Division 23 HVAC; no work is required under Division 25 BAS. Bi-directional (read/write) factory installed BACnet gateway between the BAS and ASHP control panel specified with ASHP under Division 23 HVAC; control wiring specified under Division 25 BAS. ASHP vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping across ASHP points to the BAS.
Disconnects or circuit breakers are specified under Division 23 HVAC where specifically called for in equipment schedules or specifications to be factory installed with equipment. Otherwise all disconnects are specified under Division 26 Electrical.
Emergency override switches, status lights and other refrigerant machinery room controls as required by CMC are specified under Division 25 BAS.
TDS controller, bleed valve, injector pump, make-up water flow meter, and all other water treatment system controls are specified under Division 23 HVAC. Field wiring of all components is specified under Division 25 BAS.
### INTERFACE / RESPONSIBILITY MATRIX

<table>
<thead>
<tr>
<th>System</th>
<th>Division under which the following is specified</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power wiring (remark: 0)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control &amp; interlock wiring (remark: 0)</td>
<td></td>
</tr>
</tbody>
</table>

Network wiring and routers within building is specified under Division 25 BAS. Connection to campus IT LAN shall be wired by others to main building control panel. Division 25 BAS shall coordinate with campus IT for IP address.

120V power to BAS control panels is specified under Division 26 for the panels shown on Drawings. Power to all other control panels that may be required is specified under Division 25 BAS, coordinated with Division 26 contractor for available circuits. Division 26 contractor for available circuits.

Lighting control vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping across lighting control points to the BAS.

Power measuring sensors, installation and wiring to a single central controller with Modbus interface specified under Division 26 Electrical. Modbus gateway and network connection from gateway to BAS specified under Division 25 BAS. Power monitoring control vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping across power monitoring control points to the BAS.

Hoods, including all required fire protection devices and integral listed balancing dampers, are specified under Division 11 Food Service.

Ansul type fire protection system is specified under Division 11 Food Service including all control wiring between Ansul hood and fire suppression panel, power wiring to fire suppression panel, fire alarm system monitoring intertie, gas shut-off valve interlock, and circuit breaker shunt-trips for all equipment located under the hoods.

PCUs with factory pre-piped fire suppression nozzles and fusible link detector brackets for Ansul type fire protection system is specified under Division 23. Field connection, tanks, controls, fusible link detectors, and commissioning is specified under Division 11 Food Service as part of hood fire protection system.

Duct access doors required for access to control devices where required specified under Division 23 HVAC.

Actuators for motorized dampers supplied with fans or hoods where scheduled on HVAC drawings are specified under Division 23 HVAC, mounted but not wired.

BACnet gateway to BAS specified in the Division 23 HVAC, factory installed, with connection of gateway to BAS specified under Division 25 BAS. AC vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping AC control points to the BAS.

Snorkel specified under Division 11. Snorkel damper/air valve specified under Division 23.

Control transformers for terminal boxes shall be centralized in control panels specified under Division 25 BAS.

Factory wired control transformer, safeties and contactors with single point power wiring connection specified under Division 23 HVAC.

#### 1.3 INTEGRATION WITH EXISTING SYSTEM

A. Include all services required to integrate this building into existing BAS for a fully operational system.

B. Procedure
   1. Provide all controls work within the building as indicated on Drawings and in this Section.
   2. Develop all building level control system databases and control programming using existing standards and standard programming.
3. Install building databases and control programming on a temporary portable operator’s terminal provided by the Contractor. The POT shall be used for start-up, testing, and commissioning. The POT shall remain the property of the Contractor after final completion of the project.

4. Once the building BAS has been fully commissioned and accepted by the College, merge database and programming with those existing on the Control System Servers. Confirm that the merge was successful by sample testing points and sequences and approve final installation in writing.

5. Integrate graphic screens into the Central Plant graphics including adding appropriate hyperlinks so that the system operates as one integrated system.

6. Provide high level password for College operator access to the system only at this point; College will not have access to the system prior to system acceptance and integration.

1.4 CONTRACTOR PROPOSALS

A. The system requirements described in this specification are generally performance based. Where requirements are prescriptive, the intent is to provide minimum quality, not to give unfair advantage to any given manufacturer or product. If a contractor finds that a certain requirement is unduly difficult or expensive to meet, contact the Engineer prior to bid due date and an addendum modifying the requirement will be considered.

B. Where requirements are unclear, the contractor shall clarify the requirements with the Engineer before the bid due date. Where requirements continue to be unclear, the contractor’s proposal must accurately describe what is included and excluded.

C. By submitting a proposal, contractor guarantees that their proposal is in full compliance with these specifications except as specifically excluded in their proposal.

1.5 REFERENCE STANDARDS

A. Nothing in Contract Documents shall be construed to permit Work not conforming to applicable laws, ordinances, rules, and regulations. When Contract Documents differ from requirements of applicable laws, ordinances, rules and regulations, comply with documents establishing the more stringent requirement.

B. The latest published or effective editions, including approved addenda or amendments, of the following codes and standard shall apply to the BAS design and installation as applicable.

C. State, Local, and City Codes

1. CBC – California Building Code
2. CMC – California Mechanical Code
3. CEC – California Electrical Code
4. Local City and County Codes

D. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)


E. Electronics Industries Alliance

1. EIA-232 – Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
4. EIA-472 – General and Sectional Specifications for Fiber Optic Cable.
5. EIA-475 – Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications.
7. EIA-590 – Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications.

F. Underwriters Laboratories

G. National Electrical Manufacturers Association
   1. NEMA 250 – Enclosure for Electrical Equipment.

H. Institute of Electrical and Electronics Engineers (IEEE)
   2. IEEE 802.3 – CSMA/CD (Ethernet – Based) LAN.
   3. IEEE 802.4 – Token Bus Working Group (ARCNET – Based) LAN.

1.6 DEFINITIONS

A. Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAC</td>
<td>Advanced Application Controller</td>
</tr>
<tr>
<td>AH</td>
<td>Air Handler</td>
</tr>
<tr>
<td>AHU</td>
<td>Air Handling Unit</td>
</tr>
<tr>
<td>AI</td>
<td>Analog Input</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>AO</td>
<td>Analog Output</td>
</tr>
<tr>
<td>ASC</td>
<td>Application Specific Controllers</td>
</tr>
<tr>
<td>ASCII</td>
<td>American Standard Code for Information Interchange</td>
</tr>
<tr>
<td>ASHRAE</td>
<td>American Society of Heating, Refrigeration and Air Conditioning Engineers</td>
</tr>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
</tr>
<tr>
<td>A-to-D</td>
<td>Analog-to-Digital</td>
</tr>
<tr>
<td>BACnet</td>
<td>Data Communications Protocol for Building Automation and Control Systems</td>
</tr>
<tr>
<td>BC</td>
<td>Building Controller</td>
</tr>
<tr>
<td>BIBB</td>
<td>BACnet Interoperability Building Blocks</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>BTL</td>
<td>BACnet Testing Laboratory</td>
</tr>
<tr>
<td>CAD</td>
<td>Computer Aided Drafting</td>
</tr>
<tr>
<td>CHW</td>
<td>Chilled Water</td>
</tr>
<tr>
<td>CHWR</td>
<td>Chilled Water Return</td>
</tr>
<tr>
<td>CHWS</td>
<td>Chilled Water Supply</td>
</tr>
<tr>
<td>COV</td>
<td>Change of Value</td>
</tr>
<tr>
<td>CSS</td>
<td>Control Systems Server</td>
</tr>
<tr>
<td>CU</td>
<td>Controller or Control Unit</td>
</tr>
<tr>
<td>CV</td>
<td>Constant Volume</td>
</tr>
<tr>
<td>CW</td>
<td>Condenser Water</td>
</tr>
<tr>
<td>CWR</td>
<td>Condenser Water Return</td>
</tr>
<tr>
<td>CWS</td>
<td>Condenser Water Supply</td>
</tr>
<tr>
<td>DBMS</td>
<td>Database Management System</td>
</tr>
<tr>
<td>DDC</td>
<td>Direct Digital Control</td>
</tr>
<tr>
<td>DHW</td>
<td>Domestic Hot Water</td>
</tr>
<tr>
<td>DI</td>
<td>Digital Input</td>
</tr>
<tr>
<td>DO</td>
<td>Digital Output</td>
</tr>
<tr>
<td>D-to-A</td>
<td>Digital-to-Analog</td>
</tr>
<tr>
<td>BAS</td>
<td>Building Automation System</td>
</tr>
<tr>
<td>EMT</td>
<td>Electrical Metallic Tubing</td>
</tr>
<tr>
<td>EP</td>
<td>Electro-Pneumatic</td>
</tr>
<tr>
<td>ETL</td>
<td>Edison Testing Laboratories</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>HHD</td>
<td>Hand Held Device</td>
</tr>
<tr>
<td>HOA</td>
<td>Hand-Off-Automatic</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating, Ventilating and Air-Conditioning</td>
</tr>
<tr>
<td>HTTP</td>
<td>Hyper-Text Transfer Protocol</td>
</tr>
<tr>
<td>I/O</td>
<td>Input/output</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
</tr>
<tr>
<td>LANID</td>
<td>LAN Interface Device</td>
</tr>
<tr>
<td>MAC</td>
<td>Medium Access Control</td>
</tr>
<tr>
<td>MHz</td>
<td>Megahertz</td>
</tr>
<tr>
<td>MS/TP</td>
<td>Master-Slave/Token-Passing</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Accessible</td>
<td>Locations that can be reached with no more than a ladder to assist access and without having to remove permanent partitions or materials. Examples include inside mechanical rooms, mechanical equipment enclosures, instrument panels, and above suspended ceilings with removable tiles.</td>
</tr>
<tr>
<td>BACnet Interoperability Building Blocks</td>
<td>A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device in a specification.</td>
</tr>
<tr>
<td>BACnet/BAConet Standard</td>
<td>BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.</td>
</tr>
<tr>
<td>Change of Value</td>
<td>An event that occurs when a digital point changes value or an analog value changes by a predefined amount.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Client</td>
<td>A device that is the requestor of services from a server. A client device makes requests of and receives responses from a server device.</td>
</tr>
<tr>
<td>Concealed</td>
<td>Embedded in masonry or other construction, installed in furred spaces, within double partitions, above hung ceilings, in trenches, in crawl spaces, or in enclosures.</td>
</tr>
<tr>
<td>Continuous Monitoring</td>
<td>A sampling and recording of a variable based on time or change of state (such as trending an analog value, monitoring a binary change of state).</td>
</tr>
<tr>
<td>Contract Documents</td>
<td>Specifications, drawings, and other materials provided with request for bids.</td>
</tr>
<tr>
<td>Control Systems Server</td>
<td>A computer(s) that maintain(s) the systems configuration and programming database.</td>
</tr>
<tr>
<td>Controller</td>
<td>Intelligent stand-alone control device. Controller is a generic reference to BCs, AACs, and ASCs.</td>
</tr>
<tr>
<td>Direct Digital Control</td>
<td>Microprocessor-based control including Analog/Digital conversion and program logic.</td>
</tr>
<tr>
<td>Building Automation System</td>
<td>The entire integrated management and control system.</td>
</tr>
<tr>
<td>Equal</td>
<td>Approximately equal in material types, weight, size, design, quality, and efficiency of specified product.</td>
</tr>
<tr>
<td>Exposed</td>
<td>Not installed underground or concealed.</td>
</tr>
<tr>
<td>Furnish</td>
<td>To purchase, procure, acquire and deliver complete with related accessories.</td>
</tr>
<tr>
<td>Gateway</td>
<td>Bi-directional protocol translator connecting control systems that use different communication protocols.</td>
</tr>
<tr>
<td>Hand Held Device</td>
<td>Manufacturer’s microprocessor based portable device for direct connection to a field Controller.</td>
</tr>
<tr>
<td>Inaccessible</td>
<td>Locations that do not meet the definition of accessible. Examples include inside furred walls, pipe chases and shafts, or above ceilings without removable tiles.</td>
</tr>
<tr>
<td>Indicated, shown or noted</td>
<td>As indicated, shown or noted on drawings or specifications.</td>
</tr>
<tr>
<td>Install</td>
<td>To erect, mount and connect complete with related accessories.</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>Gauges, thermometers and other devices mounted in ductwork or piping that are not a part of the BAS.</td>
</tr>
<tr>
<td>IT LAN</td>
<td>Reference to the facility’s Information Technology network, used for normal business-related e-mail and Internet communication.</td>
</tr>
<tr>
<td>LAN Interface Device</td>
<td>Device or function used to facilitate communication and sharing of data throughout the BAS.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Local Area Network</td>
<td>Computer or control system communications network limited to local building or campus.</td>
</tr>
<tr>
<td>Master-Slave/Token Passing</td>
<td>Data link protocol as defined by the BACnet standard.</td>
</tr>
<tr>
<td>Motor Controllers</td>
<td>Starters, variable speed drives, and other devices controlling the operation of motors.</td>
</tr>
<tr>
<td>Native BACnet Device</td>
<td>A device that uses BACnet for communication. A device may also provide gateway functionality and still be described as a Native BACnet device.</td>
</tr>
<tr>
<td>Native BACnet System</td>
<td>A network composed only of Native BACnet Devices without gateways.</td>
</tr>
<tr>
<td>Open Database Connectivity</td>
<td>An open standard application-programming interface for accessing a database developed. ODBC compliant systems make it possible to access any data from any application, regardless of which database management system is handling the data.</td>
</tr>
<tr>
<td>Open Connectivity</td>
<td>OPC is an interoperability standard developed for industrial applications. OPC compliant systems make it possible to access or exchange data from any application, regardless of which database management system is handling the data.</td>
</tr>
<tr>
<td>Operator Interface</td>
<td>A device used by the operator to manage the BAS including OWSs, POTs, and HHDs.</td>
</tr>
<tr>
<td>Operator Workstation</td>
<td>The user's interface with the BAS system. As the BAS network devices are stand-alone, the OWS is not required for communications to occur.</td>
</tr>
<tr>
<td>Owner</td>
<td>The Owner or their designated representatives.</td>
</tr>
<tr>
<td>Piping</td>
<td>Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation and related items.</td>
</tr>
<tr>
<td>Points</td>
<td>All physical I/O points, virtual points, and all application program parameters.</td>
</tr>
<tr>
<td>Point-to-Point</td>
<td>Serial communication as defined in the BACnet standard.</td>
</tr>
<tr>
<td>Portable Operators Terminal</td>
<td>Laptop PC used both for direct connection to a controller and for remote dial up connection.</td>
</tr>
<tr>
<td>Primary Controlling LAN</td>
<td>High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs.</td>
</tr>
<tr>
<td>Protocol Implementation Conformance Statement</td>
<td>A written document that identifies the particular options specified by BACnet that are implemented in a device.</td>
</tr>
<tr>
<td>Provide</td>
<td>Furnish, supply, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.</td>
</tr>
<tr>
<td>Reviewed, approved, or directed</td>
<td>Reviewed, approved, or directed by or to Owner’s Representative.</td>
</tr>
<tr>
<td>Router</td>
<td>A device that connects two or more networks at the network layer.</td>
</tr>
</tbody>
</table>
### Term | Definition
--- | ---
Secondary Controlling LAN | LAN connecting AACs and ASCs.
Server | A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.
Standardized Query Language | SQL - A standardized means for requesting information from a database.
Supervisory LAN | Ethernet-based LAN connecting Primary Controller LANs with each other and OWSs, CSS, and THS. See System Architecture below.
Supply | Purchase, procure, acquire and deliver complete with related accessories.
Wiring | Raceway, fittings, wire, boxes and related items.
Work | Labor, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation.

### 1.7 QUALITY ASSURANCE

**A. Materials and Equipment**

1. Manufacturer’s Qualifications: See 2.1 for approved manufacturers.

**B. Installer**

1. The following are approved BAS contractors:
   a. Sunbelt. Marc Annicchero mannicchero@sunbeltcontrols.com
   b. Air Systems. Mike Putich Mike.Putich@airsystemsinc.com
   c. ASG: Tony Skibinski tskibinski@asgbms.com

2. BAS Contractor’s Project Manager Qualifications: Individual shall specialize in and be experienced with direct digital control system installation for not less than 3 years. Project Manager shall have experience with the installation of the proposed direct digital control equipment product line for not less than 2 projects of similar size and complexity. Project Manager must have proof of having successfully completed the most advanced training offered by the manufacturer of the proposed product line.

3. BAS Contractor’s Programmer Qualifications: Individual(s) shall specialize in and be experienced with direct digital control system programming for not less than 3 years and with the proposed direct digital control equipment product line for not less than 1.5 years. Programmers must show proof of having successfully completed the most advanced programming training offered by the vendor of the programming application on the proposed product line.

4. BAS Contractor’s Lead Installation Technician Qualifications: Individual(s) shall specialize in and be experienced with direct digital control system installation for not less than 3 years and with the proposed direct digital control equipment product line for not less than 1.5 years. Installers must show proof of having successfully completed the installation certification training offered by the vendor of the proposed product line.

5. BAS Contractor’s Service Qualifications: The installer must be experienced in control system operation, maintenance and service. BAS Contractor must document a minimum
5-year history of servicing installations of similar size and complexity. Installer must also document at least a 1-year history of servicing the proposed product line.

6. Installer’s Response Time and Proximity
   a. Installer must maintain a fully capable service facility within 50 miles of the subject Project. Service facility shall manage the emergency service dispatches and maintain the inventory of spare parts.
   b. Installer must demonstrate the ability to meet the emergency response times listed

7. Electrical installation shall be by manufacturer-trained electricians
   a. Exception: Roughing in wiring and conduit and mounting panels may be subcontracted to any licensed electrician.

1.8 SUBMITTALS

A. No work may begin on any segment of this Project until the related submittals have been reviewed for conformity with the design intent and the Contractor has responded to all comments to the satisfaction of the Owner’s Representative.

B. Submit drawings and product data as hereinafter specified. Conditions in this Section take precedence over conditions in Division 1 or Section 230501 Basic Mechanical Materials and Methods.

C. Submittal Schedule: Submittal schedule shall be as follows unless otherwise directed by the Owner’s Representative:
   1. Allow 10 working days for approval, unless Owner’s Representative agrees to accelerated schedule.
   2. Submittal Package 0 (Qualifications) shall be submitted with bid.
   3. Submittal Package 1 (Hardware and Shop Drawings) shall be submitted in accordance with schedule established by the Owner in bid documents.
   4. Submittal Package 2 (Programming and Graphics) and shall be submitted no less than 30 days before software is to be installed in field devices.
   5. Submittal Package 3 (Functional Testing) shall be submitted no less than 30 days prior to conducting tests.
   6. Submittal Package 4 (Training Materials) shall be submitted no less than 14 days prior to conducting first training class.
   7. Submittal Package 5 (Post-Construction Trend Logs) shall be submitted after demonstration tests are accepted and systems are in full automatic operation. The list of points to be trended shall be submitted for approval 14 days prior to the start of the trend collection period.

D. Submission and Resubmission Procedure
   1. Optional Pre-Submittals. At Contractor’s option, electronic submittals indicated below may be submitted unofficially via email directly to the Engineer for review and comment prior to formal submission. Comments provided by the Engineer are not official and may be changed or additional comments may be provided on the formal submittal. The intent of pre-submittals is to reduce paperwork and review time.
   2. Each submittal shall have a unique serial number that includes the associated specification section followed by a number for each sub-part of the submittal for that specification section, such as SUBMITTAL 250000-01.
   3. Each resubmittal shall have the original unique serial number plus unique revision number such as SUBMITTAL 250000-01 REVISION 1.
   4. Submit one copy of submittal in electronic format specified under each submittal package below. Submissions made in the wrong format will be returned without action.
5. Owner’s Representative will return a memo or mark-up of submittal with comments and corrections noted where required.

6. Make corrections
   a. Revise initial submittal to resolve review comments and corrections.
   b. Indicate any changes that have been made other than those requested.
   c. Clearly identify resubmittal by original submittal number and revision number.

7. Resubmit revised submittals until no exceptions are taken.

8. Once submittals are accepted with no exceptions taken, provide
   a. Complete submittal of all accepted drawings and products in a single electronic file.
   b. Photocopies or electronic copies for coordination with other trades, if and as required by the General Contractor or Owner’s Representative.

E. Submittals Packages

1. Submittal Package 0 (Qualifications)
   a. Provide Installer and Key personnel qualifications as specified in Paragraph 1.7B.
   b. Format: Word-searchable format per Paragraph 1.9C.3.

2. Submittal Package 1 (Hardware and Shop Drawings)
   a. Hardware
      1) Organize by specification section and device tags as tagged in these specifications.
      2) Do not submit products that are not used even if included in specifications.
      3) Include a summary table of contents listing for every submitted device:
         a) Tab of submittal file/binder where submittal is located
         b) Device tag as tagged in these specifications (such as TS-1A, FM-1)
         c) Specification section number (down to the lowest applicable heading number)
         d) Whether device is per specifications and a listed product or a substitution
         e) Manufacturer
         f) Model number
         g) Device accuracy (where applicable)
         h) Accuracy as installed including wiring and A/D conversion effects (where applicable)
      4) Submittal shall include manufacturer’s description and technical data, such as performance data and accuracy, product specification sheets, and installation instructions for all control devices and software.
      5) When manufacturer’s cut-sheets apply to a product series rather than a specific product, the data specifically applicable to the Project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements.
      6) Format: Word-searchable format per Paragraph 1.9C.3.
   b. Shop Drawings
      1) System architecture one-line diagram indicating schematic location of all control units, workstations, LAN interface devices, gateways, etc. Indicate address and type for each control unit. Indicate media, protocol, baud rate, and type of each LAN.
      2) Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. The
schematics provided on Drawings shall be the basis of the schematics with respect to layout and location of control points.

3) All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.

4) Label each input and output with the appropriate range.

5) Device table (Bill of Materials). With each schematic, provide a table of all materials and equipment including:
   a) Device tag as indicated in the schematic and actual field labeling (use tag as indicated in these specifications where applicable and practical)
   b) Device tag as indicated in these specifications where applicable and if it differs from schematic device tag
   c) Description
   d) Proposed manufacturer and model number
   e) Range
   f) Quantity

6) With each schematic or on separate valve sheet, provide valve and actuator information including pipe size, valve size, \( C_v \), design flow, target pressure drops, actual design pressure drops, manufacturer, model number, close off rating, etc. Indicate normal positions of fail-safe valves and dampers.

7) Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

8) Details of control panels, including controllers, instruments, and labeling shown in plan or elevation indicating the installed locations.

9) Floor plans: None required.

10) Format
   a) Sheets shall be consecutively numbered.
   b) Each sheet shall have a title indicating the type of information included and the mechanical/electrical system controlled.
   c) Table of Contents listing sheet titles and sheet numbers.
   d) Legend and list of abbreviations.
   e) Schematics
      (1) Word searchable pdf format.
      (2) 21-inch x 15 inch or 17 inch x 11 inch.

   c. Do not include sequence of controls on shop drawings or equipment submittals; they are included in Submittal Package 2.

3. Submittal Package 2 (Programming and Graphics)
   a. A detailed description of point naming convention conforming to Paragraph 3.12B to be used for all software and hardware points, integrated with existing database convention.
   b. A list of all hardware and software points identifying their full text names, device addresses and descriptions.
   c. Control Logic Documentation
      1) Submit control logic program listings (graphical programming) consistent with specified English-language Sequences of Operation for all control units.
      2) Control logic shall be annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow an operator to
relate each program component (block or line) to corresponding portions of the specified Sequence of Operation.

3) Include specified English-language Sequences of Operation of each control sequence updated to reflect any suggested changes made by the Contractor to clarify or improve the sequences. Changes shall be clearly marked. SOO shall be fully consistent with the graphical programming. (An electronic version of the sequences of controls in Paragraph 3.12 will be provided to the Contractor upon request.)

4) Include control settings, setpoints, throttling ranges, reset schedules, adjustable parameters and limits.

5) Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation.

d. Graphic screens of all required graphics provided in final colors.

e. Format

1) Points list: Word-searchable format per Paragraph 1.9C.3.
2) Programming: Native ALC Eikon.
3) Programming and operating manual: Word-searchable format per Paragraph 1.9C.3.
4) Graphics: Graphical electronic format (pdf, png, etc.).

4. Submittal Package 3 (Functional Testing)

a. Provide pre-functional test forms as required by Paragraph 3.15B.1.a.

b. Provide functional test forms as required by Paragraph 3.15B.2.

c. Format: Word-searchable format per Paragraph 1.9C.3.

5. Submittal Package 4 (Training Materials)

a. Provide training materials as required by Paragraph 3.16.

b. Format: Word-searchable format per Paragraph 1.9C.3.

6. Submittal Package 5 (Trend Logs)

a. Provide a list of points being trended along with trend interval or change-of-value per Paragraph 3.15I.2.d.

b. Provide trend logs as required by Paragraph 3.15I.

1.9 COMPLETION REQUIREMENTS

A. Procedure

1. Until the documents required in this Section are submitted and approved, the system will not be considered accepted and final payment to Contractor will not be made.

2. Before requesting acceptance of Work, submit one set of completion documents for review and approval of Owner.

3. After review, furnish quantity of sets indicated below to Owner.

B. Completion Documents

1. Operation and Maintenance (O & M) Manuals. Provide in both paper and electronic format per Paragraph 1.9C.

a. Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual.

b. As-built versions of the submittal product data. Submittal data shall be located in tabs along with associated maintenance information.
c. Engineering, Installation, and Maintenance Manual(s) that explain how to design and install new points, panels, and other hardware; preventive maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.

d. Complete original issue documentation, installation, and maintenance information for all third-party hardware and software provided, including computer equipment and sensors.

e. A list of recommended spare parts with part numbers and suppliers.

f. Operators Manual with procedures for operating the control systems, including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.

g. Programming Manuals with a description of the programming language, control block descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the programming editor.

h. Recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions.

i. A listing and documentation of all custom software for the Project created using the programming language, including the set points, tuning parameters, and point and object database.

j. English language control sequences updated to reflect final programming installed in the BAS at the time of system acceptance.

k. A BACnet Protocol Implementation Conformance Statement (PICS) for each type of controller and operator interface.

2. Complete original issue electronic copy for all software provided, including operating systems, programming language, operator workstation software, and graphics software.

3. Complete electronic copy of BAS database, user screens, setpoints and all configuration settings necessary to allow re-installation of system after crash or replacement of server, and resume operations with the BAS in the same configuration as during owner sign-off.

4. Project Record Drawings

   a. As-built versions of the submittal drawings in reproducible paper and electronic format per Paragraph 1.9C.

   b. As-built network architecture drawings showing all BACnet nodes including a description field with specific controller and device identification, description and location information.

5. Commissioning Reports. Completed versions of all Pre-functional, Functional, and Demonstration Commissioning Test reports, calibration logs, etc., per Paragraph 3.15B.

6. Copy of inspection certificates provided by the local code authorities.

7. Written guarantee and warranty documents for all equipment and systems, including the start and end date for each.

8. Training materials as required

9. Contact information. Names, addresses, and 24-hour telephone numbers of contractors installing equipment, and the control systems and service representatives of each.

C. Format of Completion Documents

1. Provide the type and quantity of media listed in table below.

2. Project database, programming source files, and all other files required to modify, maintain, or enhance the installed system shall be provided in their source format and compiled format (where applicable).

3. Where electronic copies are specified, comply with the following:
a. Provide in word-searchable electronic format; acceptable formats are MS Word, Adobe Acrobat (pdf), and HTML; submit other formats for review and approval prior to submission; scanned paper documents not acceptable.

b. For submittals, provide separate file for each type of equipment.

c. Control sequences shall be in MS Word.

<table>
<thead>
<tr>
<th>Document</th>
<th>Paper (binder or bound)</th>
<th>Electronic Loaded onto Flash Drive</th>
<th>Loaded onto CSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. O&amp;M Manual</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2. Project database including all source files</td>
<td>–</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3. Project Record Drawings</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4. Control sequences</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5. Commissioning Reports</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6. Inspection Certificates</td>
<td>1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>7. Warranty documents</td>
<td>1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>8. Training materials</td>
<td>1 per trainee</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9. Contact information</td>
<td>1</td>
<td>–</td>
<td>1</td>
</tr>
</tbody>
</table>

D. Permanent On-site Documentation

1. In panels, provide the following in a sufficiently permanent manner such that documentation cannot be easily removed (and lost):

a. Point list of all points in panel.

b. Shop drawings for devices in panel.

1.10 BAS DESIGN

A. System Architecture

1. Use ALC DDC controls on Accutrol Lab Air Valves

2. General

a. The system provided shall incorporate hardware resources sufficient to meet the functional requirements specified in this Section. Include all items not specifically itemized in this Section that are necessary to implement, maintain, and operate the system in compliance with the functional intent of this Section.

b. The system shall be configured as a distributed processing network(s) capable of expansion as specified herein.

c. The existing Campus BAS consists of a control system server interconnected by a high speed Supervisory LAN to each campus building and facility. This project includes integrating building level BCs and other control devices into the campus system.

1) Within the building, the BAS shall be standalone and not rely on any 3rd party networks, such as the Campus IT LAN.

2) To communicate with the central CSS (and internet via VPN), the building Supervisory LAN shall connect via router, provided under Division 25, to the Campus IT LAN, provided by the College IT group. Locate in building MDF or other location as directed by the College IT group.
d. All control products provided for this Project shall comprise an interoperable Native BACnet System. All control products provided for this Project shall conform to ANSI/ASHRAE Standard 135.

3. BAS Network Architecture
   a. Supervisory LAN: The LAN shall be an Ethernet-based, 100 or 1000 Mbps network connecting the server and OWS(s) and to certain gateways as specified herein. Provide this as a dedicated LAN for the control system; the Campus IT LAN shall not be used for this purpose. LAN shall be IEEE 802.3 Ethernet with switches and routers that support 100 Mbps minimum throughput. Power-line carrier communication are not acceptable for communications. This network shall be BACnet/IP as defined in the BACnet standard, and shall share a common network number for the Ethernet backbone, as defined in BACnet.
      1) Supervisory LAN shall be extended to the following mechanical rooms (to allow POTs to connect to system using browser and to improve throughput of trend date)
         2) ASHP
         3) Penthouse AHU, EF
   b. Primary Controller LAN (Primary LAN): High-speed, peer-to-peer communicating LAN used to connect BCs, AACs, and certain gateways where specified herein. The Primary LAN communicates exclusively control information. Acceptable technologies include and are limited to:
      1) Ethernet (IEEE802.3)
      2) ARCNET (IEEE802.4)
   c. Secondary Controller LAN (Secondary LAN): Network used to connect ASCs and certain gateways where specified herein. These may be Master Slave/ Token Passing (MS/TP) in addition to those allowed for Primary Controller LANs. Network speed versus the number of controllers on the LAN shall be dictated by the response time and trending requirements.

4. Operator Interfaces and Servers. The Control Systems Server (CSS) and Operator interface devices are existing. No additional CSS, OWS, or POT shall be provided as a part of this project. See Paragraph 1.3 for temporary CSS requirements.

5. Controllers. The BCs, AACs, and ASCs shall monitor, control, and provide the field interface for all points specified.

6. Gateways
   a. See Paragraph 2.4C for a list of gateways and routers.
   b. Where gateways are used, critical points shall be hardwired from the BAS to the controlled device, rather than using the gateway, to avoid problems with gateway failures, currently a common problem. Critical points are those that are essential for proper operation and are listed in points list as separate points. Where listed, these points shall be hardwired even when available through gateway.

B. System Performance
   1. The communication speed between the controllers, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. This includes when system is collecting trend data for commissioning and for long term monitoring. (See Paragraph 3.15I.) In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein, assuming no other simultaneous operator activity. Reconfigure LAN as necessary to accomplish these performance requirements. This does not apply to gateways and their interaction with non-BAS-vendor equipment.
a. Object Command: The maximum time between an operator command via the operator interface to change an analog or binary point and the subsequent change in the controller shall be less than 5 seconds.

b. Object Scan: All changes of state and change of analog values will be transmitted over the network such that any data used or displayed at a controller or workstation will have been current within the previous 10 seconds.

c. Graphics Scan: The maximum time between an operator’s selection of a graphic and it completely painting the screen and updating at least 10 points shall be less than 10 seconds.

d. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation or broadcast (where so programmed) shall not exceed 10 seconds for a Level 1 alarm, 20 seconds for alarm levels 2 and 3, and 30 seconds for alarm levels 4 and 5. All workstations on the onsite network must receive alarms within 5 seconds of each other.

e. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.

f. Control Loop Performance: Programmable controllers shall be able to execute DDC PID control loops at a selectable frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.

2. Sensor selection, wiring method, use of transmitters, A-to-D conversion bits, etc. shall be selected and adjusted to provide end-to-end (fluid to display) accuracy at or better than those listed in the following table.

<table>
<thead>
<tr>
<th>Measured Variable</th>
<th>Reported Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space drybulb temperature</td>
<td>±1ºF</td>
</tr>
<tr>
<td>Ducted Air drybulb temperature</td>
<td>±0.5ºF</td>
</tr>
<tr>
<td>Mixed Air drybulb temperature</td>
<td>±1ºF</td>
</tr>
<tr>
<td>Outside Air drybulb temperature</td>
<td>±0.5ºF</td>
</tr>
<tr>
<td>Chilled and Condenser Water Temperature at central plant mains only</td>
<td>±0.5ºF</td>
</tr>
<tr>
<td>Chilled and Condenser Water Temperature – general</td>
<td>±0.5ºF</td>
</tr>
<tr>
<td>Hot Water Temperature</td>
<td>±1ºF</td>
</tr>
<tr>
<td>Chilled Water Delta-T (supply to return) at central plant main supply or return only</td>
<td>±0.15ºF</td>
</tr>
<tr>
<td>Relative Humidity – general</td>
<td>±5% RH</td>
</tr>
<tr>
<td>Relative Humidity – outdoor air</td>
<td>±3% RH</td>
</tr>
<tr>
<td>Water and Gas Flow</td>
<td>±1% of reading</td>
</tr>
<tr>
<td>Airflow (terminal)</td>
<td>±10% of reading</td>
</tr>
<tr>
<td>Airflow (measuring stations)</td>
<td>±5% of reading</td>
</tr>
<tr>
<td>Air Pressure (ducts)</td>
<td>±0.05 inches</td>
</tr>
<tr>
<td>Air Pressure (space)</td>
<td>±0.01 inches</td>
</tr>
<tr>
<td>Water Pressure</td>
<td>±2% of reading</td>
</tr>
<tr>
<td>Electrical power</td>
<td>1% of reading</td>
</tr>
<tr>
<td>Carbon Dioxide (CO2)</td>
<td>±75 ppm</td>
</tr>
</tbody>
</table>

1.11 OWNERSHIP OF PROPRIETARY MATERIAL

A. All project-developed software and documentation shall become the property of the Owner. These include, but are not limited to:

1. Project graphic images
2. Record drawings
3. Project database
4. Project-specific application programming code
5. All documentation

1.12 WARRANTY

A. At the successful completion of the final testing, commissioning, and demonstration phase in accordance with the terms of this specification, if equipment and systems are operating satisfactorily to the Owner, the Owner shall certify in writing that the control system has been accepted. The date of acceptance shall be the start of the warranty period.

B. Guarantee all materials, equipment, apparatus and workmanship (including programming) to be free of defective materials and faulty workmanship for the following periods from date of acceptance:
   1. BCs, AACs, and ASCs: two years
   2. Valve and damper actuators: five years
   3. All else: one year

C. Provide new materials, equipment, apparatus and labor to replace that determined by Owner to be defective or faulty.

D. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. Contractor shall respond to the Owner’s request for warranty service within 24 hours during normal business hours.

E. Sequence of operation programming bugs (both due to programming misinterpretations and sequence errors) shall be corrected and any reasonable control sequence changes required to provide proper system operation shall be provided at no additional cost to the Owner during this period.

1.13 WARRANTY MAINTENANCE

A. The Contractor shall warrant parts and installation work due to malfunction or incorrect initial installation, unless the owner provides clear and convincing evidence that a specific problem is the result of such changes to the BAS.

B. At no cost to the Owner, provide maintenance services for software and hardware components during the warranty period as specified below:
   1. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming shall be corrected and repaired following notification by the Owner to the Contractor.
      a. Response by telephone to any request for service shall be provided within eight working hours (contractor specified 40 hr. per week normal working period) of the Owner’s initial request for service.
      b. In the event that the malfunction, failure, or defect is covered under warranty, at least one technician, trained in the system to be serviced, shall be dispatched to the Owner’s site within three working days of the Owner’s initial request for such services, as specified.
      c. Seasonal tuning of setpoint variables is not considered part of warranty as the sequence of operations does not change.
2. Owner’s Telephonic Request for Service: Contractor shall specify a maximum of three telephone numbers for Owner to call in the event of a need for service. At least one of the lines shall be attended continuously (24/7). Alternatively, pagers/SMS can be used for technicians trained in system to be serviced. One of the three paged/texted technicians shall respond to every call within 15 minutes.

3. Documentation: Record drawings and software documentation shall be updated as required to reflect any and all changes made to the system or programming during the warranty period.

PART 2 - PRODUCTS

2.1 PRIMARY BAS MANUFACTURER

A. Automated Logic Corp.

B. Accutrol Lab Air Valves with Automated Logic Corp controllers.

C. No Equal

2.2 GENERAL

A. Materials shall be new, the best of their respective kinds without imperfections or blemishes and shall not be damaged in any way.

B. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

C. All controllers, associated hardware (repeaters, routers, etc.), sensors, and control devices shall be fully operational and maintain specified accuracy at the anticipated ambient conditions of the installed location as follows:

1. Outdoors or in harsh ambient conditions: -20°C to 55°C (-4°F to 130°F), 10% RH to 90% RH noncondensing.

2. Conditioned spaces or mechanical rooms: 0°C to 40°C (32°F to 104°F), 10% RH to 80% RH noncondensing.

2.3 CONTROLLERS

A. Building Controller (BC)
   1. ALC ME-series

B. Advanced Application Specific Controller (AAC)
   1. ALC SE-series

C. Application Specific Controller (ASC)
   1. ALC ZN-series

D. Lab Air Valves
1. Accutrol lab air valves with ALC controllers. Single controller per zone. Use expandable controller where necessary to accommodate all the zone IO.

2.4 COMMUNICATION DEVICES

A. Supervisory LAN Routers
   1. ALC LGR and AAR line

B. BACnet Gateways & Routers
   1. Gateways shall be provided to link non-BACnet control products to the BACnet internetwork. All of the functionality described in this Paragraph is to be provided by using the BACnet capabilities. Each Gateway shall have the ability to expand the number of BACnet objects of each type supported by 20% to accommodate future system changes.
   2. Each Gateway shall provide values for all points on the non-BACnet side of the Gateway to BACnet devices as if the values were originating from BACnet objects. The Gateway shall also provide a way for BACnet devices to modify (write) all points specified by the Points List using standard BACnet services.

C. Gateway and Routers

<table>
<thead>
<tr>
<th>Equipment/System</th>
<th>Interface</th>
<th>Specified Under Division:</th>
<th>Location</th>
<th>Connect to this Network:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Speed Drives</td>
<td>BACnet/MSTP</td>
<td>23</td>
<td>Each VFD</td>
<td>Secondary</td>
</tr>
<tr>
<td>ASHP</td>
<td>BACnet/MSTP</td>
<td>23</td>
<td>Each ASHP</td>
<td>Secondary</td>
</tr>
<tr>
<td>Lighting Controls</td>
<td>BACnet/IP</td>
<td>26</td>
<td>Electrical Room</td>
<td>Supervisory</td>
</tr>
<tr>
<td>Power Monitoring</td>
<td>Modbus RS-485</td>
<td>26</td>
<td>Electrical Room</td>
<td>Secondary</td>
</tr>
<tr>
<td>BTU meters</td>
<td>BACnet/MSTP</td>
<td>25</td>
<td>Each BTU meter</td>
<td>Secondary</td>
</tr>
<tr>
<td>Lab Air Valves</td>
<td>BACnet/MSTP</td>
<td>23</td>
<td>Each Air Valve</td>
<td>Secondary</td>
</tr>
<tr>
<td>Water Treatment System</td>
<td>Modbus/IP or BACnet/IP</td>
<td>23</td>
<td>WTS-1</td>
<td>Supervisory</td>
</tr>
</tbody>
</table>

2.5 BAS INTERFACE HARDWARE

A. Not required (existing)

2.6 AIR TUBING

A. Seamless copper tubing, Type L-ACR, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; except brass compression-type fittings at connections to equipment. Solder shall be 95/5 tin antimony, or other suitable lead free composition solder.

B. Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, and with flame-retardant harness for multiple tubing. Use compression or push-on brass fittings.
2.7 ELECTRIC WIRING AND DEVICES

A. All electrical work shall comply with Division 26.

B. Communication Wiring
   1. Provide all communication wiring between Building Controllers, Routers, Gateways, AACs, ASCs and local and remote peripherals (such as operator workstations and printers).
   2. Ethernet LAN: Use Fiber or Category 5 or 6 of standard TIA/EIA 68 (10baseT). Network shall be run with no splices and separate from any wiring over 30 volts.
   3. ARCnet and MS/TP LAN: Communication wiring shall be individually 100% shielded pairs per manufacturers recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over 30 volts. Shield shall be terminated and wiring shall be grounded as recommended by BC manufacturer.

C. Analog Signal Wiring
   1. Input and output signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, current or voltage analog outputs, etc. shall be twisted pair, 100% shielded if recommended or required by controller manufacturer, with PVC cover. Gauge shall be as recommended by controller manufacturer.

2.8 CONTROL CABINETS

A. All control cabinets shall be fully enclosed with hinged door and quarter-turn slotted latch.

B. Construction
   1. Indoor: NEMA 1
   2. Outdoor: NEMA 3R

C. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs or tie-wrapped. Terminals for field connections shall be UL Listed for service, individually identified per control-interlock drawings, with adequate clearance for field wiring. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover. Control terminations for field connection shall be individually identified per control Shop Drawings.

D. Provide ON/OFF power switch with over-current protection for control power sources to each local panel.

E. Provide with
   1. Framed, plastic-encased point list for all points in cabinet.
   2. Nameplates for all devices on face.

2.9 SENSORS AND MISCELLANEOUS FIELD DEVICES

A. The listing of several sensors or devices in this section does not imply that any may be used. Refer to points list in Paragraph 2.12 Points List for device specification. Only where two or more devices are specifically listed in points list (such as “FM-1 or FM-4”) may the Contractor choose among listed products.

B. Control Valves
   1. Manufacturers
2. Butterfly Valves
   a. Body: Extended neck epoxy coated cast or ductile iron with full lug pattern, ANSI Class bolt pattern to match specified flanges.
   b. Seat: EPDM replaceable, non-collapsible, phenolic backed.
   c. Disc: Polished aluminum bronze or stainless steel, pinned or mechanically locked to shaft. Sanded castings are not acceptable.
   d. Bearings: Bronze or stainless steel.
   e. Shaft: 416 stainless steel supported at three locations with PTFE bushings for positive shaft alignment.
   f. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.

3. Two Position Ball Valves
   a. Valves shall be specifically designed for two-position duty in control application with guaranteed average leak-free life span over 200,000 full stroke cycles.
   b. Industrial quality with nickel plated forged brass body and female NPT threads.
   c. Blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating (1 inch and smaller) or 400 psi rating (larger than 1 inch). The stem packing shall consist of 2 lubricated O-rings designed for on-off service and requiring no maintenance.
   d. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.
   e. No characterization disks
   f. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.
   g. Ball: Chrome plated brass
   h. Stem: Chrome plated brass

4. Modulating Characterized Ball Valves
   a. Valves shall be specifically designed for modulating duty in control application with guaranteed average leak-free life span over 200,000 full stroke cycles.
   b. Industrial quality with nickel plated forged brass body and female NPT threads.
   c. Blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 230 psi rating (2-way valves) or 400 psi rating (3-way valves). The stem packing shall consist of 2 lubricated O-rings designed for modulating service and requiring no maintenance.
   d. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.
   e. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.
   f. Ball: stainless steel
   g. Stem: stainless steel
   h. Characterizing disk held securely by a keyed ring providing equal percentage characteristic

5. Six-way Characterized Ball Valves
   a. Valves shall be specifically designed for modulating duty in control application with guaranteed average leak-free life span over 200,000 full stroke cycles.
   b. Industrial quality with nickel plated forged brass body and NPT threads.
   c. Blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 230 psi rating. The stem packing shall consist of 2 lubricated O-rings designed for modulating service and requiring no maintenance.
d. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.
e. Built-in pressure relief  
f. Close off rating: 50 psi  
g. Ball: chrome plated brass  
h. Stem: nickel plated brass  
i. Characterizing disk held securely by a keyed ring providing linear characteristic

6. Minimum valve assembly pressure ratings
   a. Chilled water: 125 psi at 60ºF  
   b. Hot water: 125 psi at 200ºF  
   c. Condenser water: 125 psi at 100ºF

7. Valve Selection
   a. Valve type  
      1) Modulating 2-way or 3-way valves  
         a) 6 inch and less: characterized ball type  
         b) 8 inch and greater: globe type  
      2) Bypass valve at primary-only variable flow pumping system outlet: Same as  
         Modulating 2-way valve.  
      3) Two-position isolation: butterfly or non-characterized ball type
   b. Valve Characteristic  
      1) 2-way valves: equal percentage or modified equal percentage.  
      2) 3-way valves controlling cooling coils and condenser water heat exchangers:  
         linear.  
      3) 3-way valves controlling heating coils: equal percentage or modified equal  
         percentage.  
      4) 6-way valves: linear  
      5) Two-position valves: not applicable. For ball valves used for two-position duty,  
         do not include characterizing disk.
   c. Valve Sizing  
      1) Modulating Water: Size valve to achieve the following full-open pressure drop  
         a) Minimum pressure drop: equal to half the pressure drop of coil or  
            exchanger.  
         b) Maximum pressure drop  
            (1) Hot water at coils: 2 psi  
            (2) Chilled water at coils: 5 psi  
         c) 3-way valves shall be selected for near minimum pressure drop. 2-way  
            and 6-way valves shall be selected near maximum pressure drop.  
         d) Flow coefficient (Cₜ) shall not be less than 1.0 (to avoid clogging)  
            unless protected by strainer. Verify from piping schematics that a  
            strainer is being provided.  
         e) Valve size shall match as close as possible the pipe size where Cₜ is  
            available in that size.  
      2) Two-position valves: Line size unless otherwise indicated on Drawings.

C. Control Dampers
   1. See Division 23
D. Actuators

1. Manufacturers
   a. Belimo
   b. No equal

2. Warranty: Valve and damper actuators shall carry a manufacturer’s 5-year warranty.

3. Electric Actuators
   a. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.
   b. Enclosure shall meet NEMA 4X weatherproof requirements for outdoor applications.
   c. Dampers. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The clamp shall be steel of a V-bolt design with associated V-shaped, toothed cradle attaching to the shaft for maximum strength and eliminating slippage via cold weld attachment. Single bolt or set screw type fasteners are not acceptable. Aluminum clamps are unacceptable.
   d. Valves. Actuators shall be specifically designed for integral mounting to valves without external couplings.
   e. Actuator shall have microprocessor-based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.
   f. Noise from actuator while it is moving shall be inaudible through a tee-bar ceiling.
   g. Actuators shall provide protection against actuator burnout using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation or use of magnetic clutches are not acceptable.
   h. Modulating Actuators. Actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. Actuators shall have positive positioning circuit so that controlled device is at same position for a given signal regardless of operating differential pressure. Actuators that internally use a floating actuator with an analog signal converter are not acceptable.
   i. Where indicated on Drawings or Points List, actuators shall include
      1) 2 to 10 VDC position feedback signal
      2) Limit (end) position switches
   j. All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC. Actuators operating on 120 VAC power shall not require more than 10 VA. Actuators operating on 230 VAC power shall not require more than 11 VA.
   k. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.
   l. Actuators shall be provided with a conduit fitting a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
   m. Where fail-open or fail-closed (fail-safe) position is required by Paragraph Error! Reference source not found., an internal mechanical, spring return mechanism shall be built into the actuator housing. Electrical capacitor type fail-safe are also acceptable. All fail-safe actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
   n. Actuators shall be capable of being mechanically and electrically paralleled to increase torque where required.
   o. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return
actuators with more than 60 inch-pound torque capacity shall have a manual crank for this purpose.

p. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed.
q. Actuators shall provide clear visual indication of damper/valve position.

4. Electric Actuators for Large Butterfly Valves

a. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.
b. The valve actuator shall consist of a capacitor-type reversible electric motor, gear train, limit switches and terminal block, all contained in a die cast aluminum enclosure.
c. Enclosure shall meet NEMA 4X weatherproof requirements for outdoor applications.
d. Output shaft shall be electroless nickel plated to prevent corrosion.
e. Actuator shall have a motor rated for minimum 75% duty cycle. Duty cycle shall be defined as running time divided by installed time at maximum torque.
f. Actuator shall be suitable for operation in ambient temperature ranging from -22°F to +150°F.
g. A pre-wired cable shall bring wiring outside enclosure to avoid necessity of opening cover.
h. Gears shall be hardened alloy steel, permanently lubricated. A self-locking gear assembly or a brake shall be supplied.
i. Actuator shall be equipped with a hand wheel for manual override to permit operation of the valve in the event of electrical power failure or system malfunction. Hand wheel must be permanently attached to the actuator. When in manual operation electrical power to the actuator will be permanently interrupted.
j. The hand wheel will not rotate while the actuator is electrically driven.
k. Actuator shall have heater and thermostat to minimize condensation within the actuator housing.
l. Provide limit (end) position switches where indicated on schematics.
m. Actuators shall provide clear visual indication of valve position.

5. Normal and Fail-Safe Position

a. Except as specified otherwise herein, the normal position (that with zero control signal) and the fail-safe position (that with no power to the actuator) of control devices and actuators shall be as indicated in table below. “Last” means last position. Actuators with a fail-safe position other than “Last” must have spring or electronic fail-safe capability.

<table>
<thead>
<tr>
<th>Device</th>
<th>Normal Position</th>
<th>Fail-Safe Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside air damper</td>
<td>CLOSED</td>
<td>CLOSED</td>
</tr>
<tr>
<td>Return air damper</td>
<td>OPEN</td>
<td>OPEN</td>
</tr>
<tr>
<td>Exhaust/relief air damper</td>
<td>CLOSED</td>
<td>CLOSED</td>
</tr>
<tr>
<td>AHU heating coil valves</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
<tr>
<td>AHU cooling coil valves</td>
<td>CLOSED</td>
<td>LAST</td>
</tr>
<tr>
<td>Equipment isolation valves</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
<tr>
<td>Hot water reheat coil valves</td>
<td>CLOSED</td>
<td>LAST</td>
</tr>
<tr>
<td>Minimum flow bypass valves</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
<tr>
<td>Fan-coil HW and CHW valves</td>
<td>CLOSED</td>
<td>LAST</td>
</tr>
<tr>
<td>VAV box dampers</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
<tr>
<td>Laboratory hood exhaust air valves</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
<tr>
<td>Laboratory supply air valves</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
<tr>
<td>Laboratory general exhaust valves</td>
<td>CLOSED</td>
<td>LAST</td>
</tr>
</tbody>
</table>
6. Valve Actuator Selection
   a. Modulating actuators for valves shall have minimum rangeability of 50 to 1.
   b. Water
      1) 2-way, 6-way, and two-position valves
         a) Tight closing against 125% of system pump shut-off head.
         b) Modulating duty against 90% of system pump shut-off head.
      2) 3-way shall be tight closing against twice the full open differential pressure for which they are sized.

7. Damper Actuator Selection
   a. Actuators shall be direct coupled. For multiple sections, provide one actuator for each section; linking or jack-shafting damper sections shall not be allowed.
   b. Provide sufficient torque as velocity, static, or side seals require per damper manufacturer’s recommendations and the following:
      1) Torque shall be a minimum 5 inch-pound per square foot for opposed blade dampers and 7 inch-pound per square foot for parallel blade dampers.
      2) The total damper area operated by an actuator shall not exceed 80% of the manufacturer’s maximum area rating.

E. General Field Devices
   1. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers and as required for proper operation in the system.
   2. It shall be the Contractor’s responsibility to assure that all field devices are compatible with controller hardware and software.
   3. Field devices specified herein are generally two-wire type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with two-wire type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, provide a transmitter and necessary regulated DC power supply, as required.
   4. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.
   5. Accuracy: As used in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis. Sensor accuracy shall be at or better than both that specifically listed for a device and as required by Paragraph 1.10B.2.

F. Temperature Sensors (TS)
   1. General
      a. Unless otherwise noted, sensors may be platinum RTD, thermistor, or other device that is commonly used for temperature sensing and that meets accuracy, stability, and resolution requirements.
      b. When matched with A/D converter of BC, AAC, or ASC, sensor range shall provide a resolution of no worse than 0.3°F (0.16 °C) (unless noted otherwise herein).
      c. Sensors shall drift no more than 0.3°F and shall not require calibration over a five-year period.
      d. Manufacturers
         1) Mamac
2) Kele Associates
3) Building Automation Products Inc.
4) Automated Logic Corp.
5) Or equal

2. Duct temperature sensors: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise.
   a. TS-1A: Single point (use where not specifically called out to be averaging in points list). Sensor probe shall be 304 stainless steel.
   b. TS-1B: Averaging. Sensor length shall be at least 1 linear foot for each 2 square feet of face area up to 25 feet maximum. Sensor probe shall be bendable aluminum.

3. Water Temperature Sensors
   a. TS-2A: Well mounted immersion sensor, ¼” stainless steel probe, double encapsulated sensor, with enclosure suitable for location.
   b. TS-2B: Same as TS-2A except provide extra precision (XP) temperature sensors to meet accuracy specified Paragraph 1.10B.2.
   c. TS-2C. See BTU-1.
   d. All piping immersion sensors shall be in one-piece machined brass or stainless-steel wells that allow removal from operating system, with lagging extension equal to insulation thickness where installed in insulated piping. Wells shall be rated for maximum system operating pressure, temperature and fluid velocity. The well shall penetrate the pipe by the lesser of approximately half the pipe diameter or eight inches. The use of direct immersion or strap-on type sensors is not acceptable.

4. Room Sensors
   a. Thermostat tags refer to the following:

<table>
<thead>
<tr>
<th>Type</th>
<th>Tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>Blank</td>
</tr>
<tr>
<td>Temperature only</td>
<td>TS-3A</td>
</tr>
<tr>
<td>With CO2</td>
<td>TS-3AC</td>
</tr>
</tbody>
</table>

1) Display
   a) Blank: Blank cover (or LCD display with display configured to be shut off and touchpad or keypad disabled)
   b) LCD: LCD display of all sensors, temperature setpoint adjustment buttons, and schedule override button

2) CO2 Sensor
   a) 400 to 1250 PPM/ ±30PPM or 3% of reading, whichever is greater.
   b) The sensor shall include automatic background calibration (ABC) logic to compensate for the aging of the infrared source and shall not require recalibration for a minimum of 5 years, guaranteed. If sensor is found to be out of calibration, supplier shall recalibrate at no additional cost to the Owner within 5 years of purchase date.
   c) Meet Title 24 requirements including calibration interval

3) For room sensors connected to terminal box controllers (such as at VAV boxes) that require calibration: Include a USB port or some other means for connection of POT for terminal box calibration. Alternative means of terminal calibration are acceptable provided they result in no cost to Work performed under Section 230593 Testing, Adjusting, and Balancing.

b. Unless otherwise indicated in points list or drawings, locate sensors as follows:
   1) Lobbies, corridors, break rooms, and public spaces: TS-3A
   2) Equipment rooms and other back-of-house spaces: TS-3A
3) Open offices: TS-3A
4) Private offices: TS-3C
5) Conference rooms, meeting rooms, etc.: TS-3C
6) Classrooms, labs, training rooms, multi-purpose rooms, etc.: TS-3C
7) Others not listed: Confirm with Engineer through RFI.

5. TS-4: Outdoor Air Sensors
   a. Enclose in fan-aspirated radiation shield that combines both active and passive aspiration to minimize the effects of radiation.
      1) Motor-driven fan draws air through the sensor chamber and exhausts it through the top of the shield.
      2) Triple-walled sensor chamber shielded by flow-through plates.
      3) Aspiration rate: minimum is 220 feet per minute.
   b. Sensor electronics mounted in watertight gasketed enclosure to prevent water seepage
   c. Manufacturer
      1) Davis Instruments 7747
      2) Kele A21
      3) Or equal

G. BTU Meter (BTU-1)
   1. Matched RTD or solid state temperature sensors with a differential temperature accuracy of +/-0.15°F.
   2. Flow meter: FM-1
   3. Unit accuracy shall be +/- 1% factory calibrated, traceable to NIST with certification.
   4. NEMA 1 enclosure.
   5. UL listed.
   6. Provide BACnet/MSTP network connection that will allow all point data to be transmitted to BAS network.
   7. I/O.
      a. BACnet Points:
         1) Supply Temperature
         2) Return Temperature
         3) Flow
         4) Energy Rate (Btu/hr.)
      b. Hardwired Points:
         1) Flow

8. Manufacturers
   a. Onicon System 20
   b. Siemens Sitrans
   c. Or Equal

H. Pressure Transmitters (PT)
   1. PT-1: Water, General Purpose
      a. Fast-response stainless steel sensor
      b. Two-wire transmitter, 4-20 mA output with zero and span adjustments
      c. Accuracy
         1) Overall Accuracy (at constant temp) ±0.5% full scale, includes non-linearity, repeatability, and hysteresis
d. Long Term Stability 0.5% FS per year
e. Pressure Limits
   1) Rated pressure: see points list
   2) Proof pressure = 3x rated pressure
   3) Burst pressure = 5x rated pressure
f. Manufacturers
   1) Setra 209
   2) Kele & Associates P51 Series
   3) Or equal

I. Differential Pressure Transmitters (DPT)
   1. DPT-1: Water, General Purpose
      a. Fast-response capacitance sensor
      b. Two-wire transmitter, 4-20 mA output with zero and span adjustments
      c. Accuracy
         1) Overall Accuracy (at constant temp) ±0.25% full scale (FS).
         2) Non-Linearity, BFSL ±0.22% FS.
         3) Hysteresis 0.10% FS.
         4) Non-Repeatability 0.05% FS.
      d. Long Term Stability 0.5% FS per year
      e. Only 316 stainless steel in contact with fluid
      f. Pressure Limits
         1) 0 to 100 psid range: 250 psig maximum static pressure rating, 250 psig maximum overpressure rating.
         2) 100 to 300 psid range: 450 psig maximum static pressure rating, 450 psig maximum overpressure rating.
      g. Include brass 5-valve assembly for single sensor devices. See Paragraph 3.11E.7.
      h. Manufacturers
         1) Setra 209 or 230
         2) Modus W30
         3) Or equal
   2. DPT-2: Not used
   3. DPT-3: Air, Duct Pressure:
      a. General: Loop powered two-wire differential capacitance cell-type transmitter.
      b. Output: two wire 4-20 mA output with zero adjustment.
      c. Overall Accuracy: ±1% of range (not of maximum range/scale)
      d. Switch selectable range:
         1) ≥ 0.5 inches water column
         2) ≤10 inches water column
         3) Select range as specified in points list or, if not listed for specified setpoint to be between 25% and 75% full-scale.
      e. Housing: Polymer housing suitable for surface mounting.
      f. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301, Davis Instruments, or equal, with connecting tubing.
      g. DPT-3A: Include LCD display of reading.
      h. DPT-3B: Same as DPT-3 except with stainless steel pitot-type static pressure sensing tips similar to Dwyer model A-301-SS, or equal.
      i. Manufacturers.
4. DPT-4: Air, Low Differential Pressure
   a. General: Loop powered, two-wire differential capacitance cell type transmitter.
   b. Output: Two-wire 4-20 mA output with zero adjustment.
   c. Overall Accuracy
      1) General: ±1% FS
      2) Underfloor: ±0.5% FS
      3) Minimum outdoor air damper DP used for minimum outdoor airflow: ±0.25% FS
   d. Range
      1) Fixed (non-switch selectable)
      2) Minimum Range: 0, -0.1, -0.25, -0.5, or -1.0 inches water column
      3) Maximum Range: +0.1, 0.25, 0.5, or 1.0 inches water column
      4) Range shall be as specified in points list or, if not listed, selected such that specified setpoint is between 25% and 75% full-scale.
   e. Housing: Polymer housing suitable for surface mounting
   f. Static Sensing Element
      1) Ambient sensor: Dwyer A-306 or 420, BAPI ZPS-ACC-10, or equal
      2) Space sensor: Kele RPS-W, BAPI ZPS-ACC-01, Dwyer A-417 or 465, Veris AA05 or equal wall plate sensor
      3) Filter or duct pressure sensor: Dwyer A-301 or equal
      4) Plenum pressure sensor: Dwyer A-421 or equal
   g. DPT-4A: Include LCD display of reading
   h. Manufacturers
      1) Setra 267
      2) Modus
      3) Air Monitor
      4) Paragon
      5) Or equal

5. DPT-5: VAV Velocity Pressure
   a. General: Loop powered two-wire differential capacitance cell type transmitter.
   b. Output: Two-wire, 4-20 mA output with zero adjustment.
   c. Calibration software shall use a minimum of two field measured points, minimum and maximum airflow, with curve fitting airflow interpolation in between.
   d. Flow transducer (including impact of A-to-D conversion) shall be capable of stably controlling to a setpoint of 0.004 inches differential pressure or lower, shall be capable of sensing 0.002 inches differential pressure or lower, and shall have a ±0.001 inches or lower resolution across the entire scale.
   e. Range: 0 to 1.5 in.w.c.
   f. Housing: Polymer housing suitable for surface mounting.
   g. Manufacturer
      1) Automated Logic
      2) No equal

J. Differential Pressure Switches (DPS)
1. DPS-1: Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential, and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range. 0°F to 160°F operating temperature range.

2. DPS-2: Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Automatic reset. Provide manufacturer’s recommended static pressure sensing tips and connecting tubing.

K. Level Sensor (LS-1)

1. Sensor Element:
   a. Capacitive
   b. Stainless steel

2. Performance
   a. Linearity and Hysteresis: ±0.1% FS
   b. Accuracy: ±0.1% of full scale at constant temperature, ±0.25% over 35°F to 70°F range
   c. Automatic barometric pressure compensation

3. Outputs: 4-20 mA or 0 to Vdc

4. Operating Temperature: -40° to +185°F

5. Housing
   a. NEMA 4X weather tight
   b. Corrosion resistant material

6. Electronics shall be fully encapsulated in marine grade epoxy, guaranteed not to leak

7. Rated for 190°F fluid temperature.

8. Manufacturer
   a. Mercoid Series CRF2
   b. Intempco LTX01
   c. Or equal

L. Current Switches (CS-1)

1. Clamp-on or solid-core

2. Range: as required by application

3. Trip Point: Automatic or adjustable
   a. Exception: Fixed setpoint (Veris H-300 or equal) may be used on direct drive constant speed fans that do not have backdraft or motorized shutoff dampers.

4. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage

5. Lower Frequency Limit: 6 Hz

6. Trip Indication: LED

7. Approvals: UL, CSA

8. May be combined with relay for start/stop

9. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing with override switch. Kele RIBX, Veris H500, or equal

10. Manufacturers
   a. Veris Industries H-608/708/808/908
   b. Serva C-2320L
   c. RE Technologies SCS1150A-LED
   d. Or equal

M. Current Transformers (CT)

a. Range: 1-10 amps minimum, 20-200 amps maximum
b. Trip Point: Adjustable
c. Output: 0-5 Vdc or 0-10 Vdc,
d. Accuracy: ±0.2% from 20 to 100 Hz.
e. Manufacturers: Kele SC100, Veris 722, or equal

N. Flow Meter (FM)

1. This is the CCCCD standard for accurate metering of water flows with very low maintenance

2. FM-1: Magnetic Flow Tube Flow Meters

a. General Requirements

   1) Sensor shall be a magnetic flow meter, which utilizes Faraday’s Law to measure volumetric fluid flow through a pipe. The flow meter shall consist of 2 elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.

   2) Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).

   3) Provide a four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used on HVAC applications provided accuracy is as specified.

   4) Flow Tube

      a) ANSI class 150 psig steel
      b) ANSI flanges
      c) Lined with

         (1) Heating hot water: PTFE, PFA, or ETFE liner rated for 210°F minimum fluid temperature
         (2) Chilled, condenser, domestic hot and cold water: Polypropylene, Ebonite PTFE, PFA, or ETFE liner rated for 140°F minimum fluid temperature

   5) Electrode and grounding material

      a) 316L Stainless steel or Hastelloy C
      b) Electrodes shall be fused to ceramic liner and not require O-rings.

   6) Electrical Enclosure: NEMA 4

   7) Approvals

      a) UL or CSA
      b) NSF Drinking Water approval for domestic water applications

   8) Performance

      a) Accuracy shall be ±0.5% of actual reading from 3 to 30 feet per second flow velocities, and ±0.015 fps from 0.04 fps to 3 fps.
      b) Stability: 0.1% of rate over six months.
      c) Meter repeatability shall be ± 0.1% of rate at velocities > 3 feet per second.
      d) Calibration: The sensor must be factory calibrated on an internationally accredited (such as NAMAS) water flow rig with accuracy better than 0.1%. Calibration shall be NIST traceable.

b. Manufacturers
1) Onicon F-3000 series
2) Siemens/Danfoss Magflo 3100
3) Krohne Optiflux 4000
4) Sparling Tigermag EP FM656
5) Or equal

O. Airflow Measuring Stations (AFMS)
   1. General. AFMS provided under this Section shall be licensed to bear the AMCA Certified Rating Seal for Airflow Measuring Stations. Ratings shall be based on tests and procedures performed in accordance with AMCA Publication 611 and comply with requirements of the AMCA Certified Ratings Program.
   2. AFMS-3. Airflow measurement device and control damper provided with air handling units.
      See Section 237300 Air Handling Units & Coils.
   3. AFMS-3
      a. Differential pressure type with uniframe DP sensor
      1) Provide quantity of DP sensors per manufacturer’s recommendations
      b. Extended flow (2 transducers, 0.05” and 0.25” range)
      c. Station mounted with expanded metal screen
      d. Analog outputs for airflow and temperature
      e. Manufacturers
         1) Air Monitor OAM-II-2111-MMAB
         2) No equal

P. Airflow Measuring Lab Air Valves
   1. Accutrol air flow valves to be used for all hoods with ALC controllers per the district standard
   2. All labs to be controlled from a single ALC controller. Individual controllers on the terminal units is not acceptable.

Q. Electric Control Components
   1. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.
      a. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
         1) AC coil pull-in voltage range of +10%, -15% or nominal voltage.
         2) Coil sealed volt-amperes (VA) not greater than 4 VA.
         3) Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
         4) Pilot light indication of power-to-coil and coil retainer clips.
      b. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load.
      c. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.
   2. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA type 1 enclosure. Manufacturer shall be Square D, Cutler-Hammer, or equal.
   3. Control Transformers and Power Supplies
a. Control transformers shall be UL Listed. Furnish Class 2 current-limiting type, or furnish over-current protection in both primary and secondary circuits for Class 2 service per NEC requirements. Mount in minimum NEMA-1 enclosure.

b. Transformer shall be proper size for application. Limit connected loads to 80% of rated capacity.

c. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100 microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection, and shall be able to withstand a 150% current overload for at least 3 seconds without trip-out or failure.

d. Separate power transformer shall be used for controllers and for actuators and other end devices that use half wave rectification.

e. Unit shall operate between 0°C and 50°C [32°F and 120°F]. EM/RF shall meet FCC Class B and VDE 0871 for Class B, and MIL-STD 810C for shock and vibration.

4. Electric Push Button Switch: Switch shall be momentary contact, oil tight, push button, with number of N.O. or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley, Kele, or equal.

5. Mechanical Timer Switch: Switch shall be mechanically spring wound with a N.O. contact or N.C. contacts as required. Timer shall be 0-60 minutes and shall not include a “hold” feature, which allows switch contacts to remain closed. Contacts shall be rated for minimum 120 VAC operation. Switch shall be C560M type, as manufactured by NSI Industries or equal.

6. Pilot Light: Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC. Unit shall be 800T type, as manufactured by Allen-Bradley, Kele, or equal.

7. Alarm Horn: Panel-mounted audible alarm horn shall be continuous tone, Sonalert solid-state electronic signal, as manufactured by Mallory, Kele, or equal.

8. Potentiometer. Wall box mounted single turn with knob numbered 0 to 10 or 0 to 100. Wall plate cover to match electrical.

9. Window switch (WS)
   a. Surface mount magnetic burglar alarm switch.
   b. Screw mount, magnet on window, switch on frame.
   c. Sealed to prevent dirt or dust contact.
   d. Color to match electrical and lighting switch plates in the room. See Division 26 and Electrical Drawings.

2.10 CALIBRATION & TESTING INSTRUMENTATION

A. Provide instrumentation required to verify readings, calibrate sensors, and test the system and equipment performance.

B. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

C. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (for example if field device is ±0.5% accurate, test equipment shall be ±0.25% accurate over same range).

2.11 SOFTWARE
A. General
   1. System software shall be the latest version of ALC WebCTRL.

B. Licensing
   1. Include licensing and hardware keys for all software packages at all workstations (OWSs and POTs) and servers.
   2. Within the limitations of the server, provide licenses for any number of users to have web access to the CSS at any given time.
   3. All operator interface, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be licensed and provided to the Owner.
   4. All operator software, including that for programming and configuration, shall be available on all workstations. Hardware and software keys to provide all rights shall be installed on all workstations.

C. Graphical User Interface Software
   1. Graphics
      a. The GUI shall make extensive use of color in the graphic pane to communicate information related to setpoints and comfort. Animated graphics and active setpoint graphic controls shall be used to enhance usability.
      b. Graphics tools used to create Web Browser graphics shall be non-proprietary and provided and installed on each OWS.
      c. Graphical display shall be 1280 x 1024 pixels or denser, 256 color minimum.
      d. Links
         1) Graphics shall include hyperlinks which when selected (clicked on with mouse button) launch applications, initiate other graphics, etc.
         2) Screen Penetration: Links shall be provided to allow user to navigate graphics logically without having to navigate back to the home graphic. See additional discussion in Paragraph 3.12E.
         3) Information Links
            a) On each MEP system and subsystem graphic, provide links to display in a new window the information listed below.
               (1) English-language as-built control sequence associated with the system. See Paragraph 1.9B.
               (2) O&M and submittal information for the devices on the graphic. See Paragraph 1.9B. This includes links to electronic O&M and submittal information for mechanical equipment supplied under Section 230501 Basic Mechanical Materials and Methods.
            b) The display shall identify the target of the link by file name/address.
            c) Information shall be displayed in electronic format that is text searchable.
            d) Window shall include software tools so that text, model numbers, or point names may be found. Source documents shall be read-only (not be editable) with this software.
      e. Point Override Feature
         1) Every real output or virtual point displayed on a graphic shall be capable of being overridden by the user (subject to security level access) by mouse point-and-click from the graphic without having to open another program or view.
         2) When the point is selected to be commanded
a) Dialog box opens to allow user to override the point (Operator Mode) or release the point (Automatic Mode). Operator Mode will override automatic control of the point from normal control programs.
b) Dialog box shall have buttons (for digital points) or a text box or slide bar (for analog points) to allow user to set the point’s value when in operator mode. These are grayed out when in automatic mode.
c) When dialog box is closed, mode and value are sent to controller.
d) Graphic is updated upon next upload scan of the actual point value.

3) A list of points that are currently in an operator mode shall be available through menu selection.

f. Point override status (if a digital point is overridden by the supervised manual override per Paragraph 2.3A or if a point is in operator mode per Paragraph 2.11C.1.e) shall be clearly displayed on graphics for each point, such as by changing color or flag.
g. The color of symbols representing equipment shall be able to change color or become animated based on status of binary point to graphically represent on/off status.

2. Alarms
a. ALC WebCTRL Enterprise Integration advanced alarm package configured as indicated below.

3. Trends
a. ALC WebCTRL Enterprise Integration trend package configured as indicated below.
b. Trend Data Storage
   1) The database shall allow applications to access the data while the database is running. The database shall not require shutting down in order to provide read-write access to the data. Data shall be able to be read from the database without interrupting the continuous storage of trend data being carried by the BAS using SQL queries.
   2) Data shall be stored in an SQL compliant database format and shall be available through the Owner’s intranet or internet (with appropriate security clearance) without having to disable BAS access to the database.
   3) The database shall not be inherently limited in size, e.g. due to software limitations or lack of a correct license. Database size shall be limited only by the size of the provided storage media (hard drive size).

4. Security Access
a. Standard ALC WebCTRL security package

5. Report Software
a. ALC WebCTRL Enterprise Integration advanced reporting package.
b. Standard reports. Prepare the following standard reports, accessible automatically without requiring definition by user.
   1) Tenant or department after-hour usage. System must be capable of monitoring tenant override requests and generating a monthly report showing the daily total time in hours that each tenant has requested after-hours HVAC services.
   3) Alarm events and status.
   4) Points in Hand (Operator Override) via Workstation command (including name of operator who made the command) or via supervised HOA switch at output, including date and time.
D. Control Programming Software

E. Miscellaneous Software
   1. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide relevant data for the application or object that help is being called from.
   2. Provide software for viewing (but not editing) electronic versions of as-built shop drawings of
      a. Mechanical, electrical, and plumbing systems in Adobe pdf format
      b. BAS drawings in Adobe pdf format

2.12 CONTROL POINTS

A. Table Column Definitions
   1. Point description
   2. Type (number in point schedule after each type refers to tag on schematics)
      a. AO: analog output
      b. AI: analog input
      c. DO: digital or binary output
      d. DI: digital or binary input
   3. Device description
      a. See Paragraph 2.9 for device definition.
   4. Trend Logging
      a. Commissioning: Where listed, point is to be trended at the basis listed for commissioning and performance verification purposes.
      b. Continuous: Where listed, point is to be trended at the basis listed continuously, initiated after system acceptance, for the purpose of future diagnostics.
      c. Trend Basis
         1) Where range of engineering units is listed, trend on a change of value (COV) basis (in other words record time stamp and value when point value changes by engineering unit listed).
         2) Where time interval is listed, trend on a time basis (in other words record time stamp and value at interval listed). All points relating to a specific piece of equipment shall be trended at the same initiation time of day so data can be compared in text format.
   5. Calibration
      a. F = factory calibration only is required (no field calibration)
      b. HH = field calibrate with handheld device. See Paragraph 3.15E.5.a.2)

B. Note that points lists below are for each system of like kind. Refer to drawings for quantity of each.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL
A. Install systems and materials in accordance with manufacturer’s instructions, roughing-in drawings and details indicated on Drawings.

B. Coordinate Work and Work schedule with other trades prior to construction.

C. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 DELIVERY, STORAGE, AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment.

B. Store equipment and materials inside and protect from weather.

3.3 IDENTIFICATION

A. General
   1. Manufacturers’ nameplates and UL or CSA labels to be visible and legible after equipment is installed.
   2. Identifiers shall match record documents.
   3. All plug-in components shall be labeled such that removal of the component does not remove the label.

B. Wiring and Tubing
   1. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2 inches of termination with the BAS address or termination number.
   2. Permanently label or code each point of field terminal strips to show the instrument or item served.
   3. All pneumatic tubing shall be labeled at each end within 2 inches of termination with a descriptive identifier.

C. Equipment and Devices
   1. Valve and damper actuators: None required.
   2. Sensors: Provide 1 inch x 3 inches x 1/8 inches black micarta or lamacoid labels with engraved white lettering, ¼ inches high. Indicate sensor identifier and function (for example “CHWS Temp”).
   3. Panels
      a. Provide 2 inches x 5 inches 1/8 inches black micarta or lamacoid labels with engraved white lettering, ½ inches high. Indicate panel identifier and service.
      b. Provide permanent tag indicating the electrical panel and circuit number from which panel is powered.
   4. Identify room sensors relating to terminal box or valves with indelible marker on sensor hidden by cover.

3.4 CUTTING, CORING, PATCHING AND PAINTING

A. Provide canning for openings in concrete walls and floors and other structural elements prior to their construction.
B. Penetrations through rated walls or floors shall be filled with a listed material to provide a code compliant fire-stop.

C. All damage to and openings in ductwork, piping insulation, and other materials and equipment resulting from Work in this Section shall be properly sealed, repaired, or re-insulated by experienced mechanics of the trade involved. Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

D. At the completion of Work, all equipment furnished under this Section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired and repainted to original finish.

3.5 CLEANING

A. Clean up all debris resulting from its activities daily. Remove all cartons, containers, crates, and other debris generated by Work in this Section as soon as their contents have been removed. Waste shall be collected and legally disposed of.

B. Materials stored on-site shall be protected from weather and stored in an orderly manner, neatly stacked, or piled in the designated area assigned by the Owner’s Representative.

C. At the completion of work in any area, clean all work and equipment of dust, dirt, and debris.

D. Use only cleaning materials recommended by the manufacturer of the surfaces to be cleaned and on surfaces recommended by the cleaning material manufacturer.

3.6 CONTROLLERS

A. General

1. Install systems and materials in accordance with manufacturer’s instructions, specifications, roughing-in drawings and details indicated on Drawings.

2. Regardless of application category listed below, each Control Unit shall be capable of performing the specified sequence of operation for the associated equipment. Except as listed below, all physical point data and calculated values required to accomplish the sequence of operation shall reside within the associated CU. Listed below are point data and calculated values that shall be allowed to be obtained from other CUs via LAN.

   a. Global points such as outdoor air temperature
   b. Requests, such as heat/cool requests, used to request operation or for setpoint reset from zones to systems and systems to plants
   c. Modes, such as system modes, used to change operating logic from plants to systems and systems to zones

3. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.

B. Controller Application Categories

1. Controllers shall comply with the application table below (X under controller type indicates acceptable controller type).
<table>
<thead>
<tr>
<th>Application Category</th>
<th>Examples</th>
<th>Acceptable Controller</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ASC</td>
</tr>
<tr>
<td>0</td>
<td>Monitoring of variables that are not used in a control loop, sequence</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>logic, or safety, such as status of sump pumps or associated float</td>
<td></td>
</tr>
<tr>
<td></td>
<td>switches, temperatures in monitored electrical rooms.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Miscellaneous heaters Constant speed exhaust fans and pumps</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Fan Coil Units Terminal Units (such as VAV Boxes) Unitary AC and HP</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>units</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>“Slow” Lab Zone –Non-Hood Dominated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(note 1)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Air Handling Units Central Hot Water Plant “Fast” Lab Zone –Hood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dominated Air-Cooled Chilled Water Plant</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Water-Cooled Chilled Water Plant</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. ALL FUNCTIONS TO BE ACCOMPLISHED BY A SINGLE CONTROLLER RATHER THAN SEVERAL CONTROLLERS INDEPENDENTLY. USE EXPANDABLE CONTROLLER WHERE NECESSARY TO ACCOMMODATE ALL THE I/O OF THE ZONE.

2. ASC Installation
   a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.
   b. ASCs that control equipment mounted in a mechanical room may either be mounted in or on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
   c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.

3. AAC and BC Installation
   a. AACs/BCs that control equipment located above accessible ceilings shall be mounted in a NEMA 1, locking enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.
   b. AACs/BCs that control equipment located in occupied spaces or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the Contractor) or in a proximate mechanical/utility room in which case it shall be enclosed in a NEMA 1, locking enclosure.

4. Lab Box Controllers:
   a. Accutrol lab air valves are to be used with ALC controllers per the district standard.

3.7 COMMUNICATION DEVICES
A. General
1. Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details indicated on Drawings.
2. Provide all interface devices and software to provide an integrated system.

B. LANID and LAN Routers
1. Provide as required
2. Connect networks to both sides of device
3. Thoroughly test to ensure proper operation
4. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted. The system shall automatically monitor the operation of all network devices and annunciate any device that goes off-line because it is failing to communicate.

C. Gateways and Routers to Equipment Controllers
1. See Paragraph 2.4C for network connection of gateways and routers.
2. Wire to networks on both sides of device.
3. Map across all monitoring and control points listed in Paragraph Error! Reference source not found.
4. Thoroughly test each point to ensure that mapping is accurate.
5. Initiate trends of points as indication in Paragraph Error! Reference source not found..

D. External Communications
1. Provide an Ethernet second port on the CSS to which the Owner can connect their Owner IT LAN (intranet), by others. Contractor shall coordinate with the Owner's Representative to establish an IP address and communications parameters to assure proper operation. This connection shall also provide access to Internet through Owner's firewall to Internet Services Provider procured by Owner.

3.8 CONTROL AIR TUBING

A. Sensor air tubing shall be sized by the Contractor.

B. All control air piping shall be concealed except in equipment rooms or unfinished areas.

C. Installation methods and materials
1. Concealed and Inaccessible: Use copper tubing or FR plastic in metal raceway. Exception: Room thermostat drops in stud walls in areas with lay-in ceiling may be FR plastic tubing.
2. Concealed and Accessible tubing (including ceiling return air plenums) shall be copper tubing or FR plastic tubing, subject to the following limitations
   a. FR tubing shall be enclosed in metal raceway when required by local code.
   b. Quantity of FR tubing per cubic foot of plenum space shall not exceed manufacturer's published data for Class 1 installation.
3. Exposed to view or damage: Use hard-drawn copper or FR plastic in metal raceway.
   a. Where copper tubing is used, a section 12 inches or less of FR plastic tubing is acceptable at final connection to control device.

D. Mechanically attach tubing to supporting surfaces. Sleeve through concrete surfaces in minimum 1-inch sleeves, extended 6 inches above floors and 1 inch below bottom surface of slabs.
E. Pneumatic tubing shall not be run in raceway containing electrical wiring.

F. Where FR tubing exits the end of raceway or junction box, provide a snap-in nylon bushing. Where pneumatic tubing exits control panels, provide bulkhead fittings. Where copper tubing exits junction boxes or panels, provide bulkhead fittings.

G. All tubing shall be number coded on each end and at each junction for easy identification.

H. All control air piping shall be installed in a neat and workmanlike manner parallel to building lines with adequate support.

I. Piping above suspended ceilings shall be supported from or anchored to structural members or other piping or duct supports. Tubing shall not be supported by or anchored to electrical raceways or ceiling support systems.

J. Brass-barbed fittings shall be used at copper-to-FR tubing junctions. Plastic slipped-over copper tubing is not acceptable.

K. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

3.9 CONTROL POWER

A. Power wiring and wiring connections required for Work in this Section shall be provided under this Section unless specifically indicated on Division 26 Drawings or Specifications. See Paragraph 1.2.
   1. See Division 26 Electrical Drawings for power locations pre-allocated for BAS system.
   2. Coordinate with Division 26 during shop drawing development for final connection location.

B. General requirements for obtaining power include the following:
   1. Electrical service to controls panels and control devices shall be provided by isolated circuits, with no other loads attached to the circuit, clearly marked at its source. The location of the breaker shall be clearly identified in each panel served by it.
   2. Where control equipment is located inside a new equipment enclosure, coordinate with the equipment manufacturer and feed the control with the same source as the equipment. If the equipment’s control transformer is large enough and of the correct voltage to supply the controls, it may be used. If the equipment’s control transformer is not large enough or not of the correct voltage to supply the controls, provide separate transformer(s).

C. Unless transformers are provided with equipment as specified in related Division 23 and 26 equipment Sections, Contractor shall provide transformers for all low voltage control devices including non-powered terminal units such as cooling-only VAV boxes and VAV boxes with hot water reheat. Transformer(s) shall be located in control panels in readily accessible locations such as Electrical Rooms.

D. Power line filtering. Provide transient voltage and surge suppression for all workstations and BCs either internally or as an external component.

3.10 CONTROL AND COMMUNICATION WIRING

A. Control and Signal Wiring

2. Line Voltage Wiring
   a. All line-voltage wiring shall meet NEC Class 1 requirements.
   b. All Class 1 wiring shall be installed in UL Listed approved raceway per NEC requirements and shall be installed by a licensed electrician.
   c. Class 1 wiring shall not be installed in raceway containing pneumatic tubing.

3. Low Voltage Wiring
   a. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
   b. Class 2 wiring shall be installed in UL Listed approved raceway as follows:
      1) Where located in unconcealed or inaccessible locations, such as:
         a) Equipment rooms
         b) Exposed to weather
         c) Exposed to occupant view
         d) Inaccessible locations such as concealed shafts and above inaccessible ceilings
      2) Class 2 wiring shall not be installed in raceway containing Class 1 wiring.
   c. Class 2 wiring need not be installed in raceway as follows:
      1) Where located in concealed and easily accessible locations, such as:
         a) Inside mechanical equipment enclosures and control panels
         b) Above suspended accessible ceilings (e.g. lay-in and spline)
         c) Above suspended drywall ceilings within reach of access panels throughout
         d) In shafts within reach of access panels throughout
         e) Nonrated wall cavities
      2) Wiring shall be UL Listed for the intended application. For example, cables used in floor or ceiling plenums used for air transport shall be UL Listed specifically for that purpose.
      3) Wiring shall be supported from or anchored to structural members neatly tied at 10-foot intervals and at least 1 foot above ceiling tiles and light fixtures. Support or anchoring from straps or rods that support ductwork or piping is also acceptable. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceilings.
      4) Install wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.
   d. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two (for example relays and transformers).

4. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

5. All field wiring shall be properly labeled at each end, with self-laminating typed labels indicating device address, for easy reference to the identification schematic. All power wiring shall be neatly labeled to indicate service, voltage, and breaker source.

6. Use coded conductors throughout with different colored conductors.

7. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

8. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the Contractor shall provide step-down transformers.

9. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
10. Size of raceway and size and type of wire shall be the responsibility of the Contractor, in keeping with the manufacturer’s recommendation and NEC requirements.

11. Include one pull string in each raceway 1 inch or larger.

12. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

13. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 inches from high-temperature equipment (for example steam pipes or flues).

14. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

15. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.

16. Terminate all control or interlock wiring.

17. Maintain updated as-built wiring diagrams with terminations identified at the jobsite.

18. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 3 feet in length and shall be supported at each end. Flexible metal raceway less than ½ inches electrical trade size shall not be used. In areas exposed to moisture liquid-tight, flexible metal raceways shall be used.

19. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings per code. Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.

20. Wire digital outputs to either the normally-closed or normally-open contacts of binary output depending on desired action in case of system failure. Unless otherwise indicated herein, wire to the NO contact except the following shall be wired to the NC contact
   a. Hot water pumps

21. Hardwire Interlocks
   a. The devices referenced in this Section are hardwire interlocked to ensure equipment shutdown occurs even if control systems are down. Do not use software (alone) for these interlocks.
   b. Hardwire device NC contact to air handler fan starter upstream of HOA switch, or to VFD enable contact.
   c. Where multiple fans (or BAS DI) are controlled off of one device and the device does not have sufficient contacts, provide a relay at the device to provide the required number of contacts.
   d. Provide for the following devices where indicated on Drawings or in Sequences of Operation:
      1) High discharge static pressure
      2) Low mixing plenum pressure

22. Shielded cable shield shall be grounded only at one end. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

B. Communication Wiring

1. Adhere to the requirements of Paragraph 3.10A in addition to this Paragraph.

2. Communication and signal wiring may be run without conduit in concealed, accessible locations as permitted by Paragraph 3.10A only if noise immunity is ensured. Contractor is fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance.

3. All cabling shall be installed in a neat and workmanlike manner. Follow all manufacturers’ installation recommendations for all communication cabling.
4. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
5. Maximum pulling, tension, and bend radius for cable installation as specified by the cable manufacturer shall not be exceeded during installation.
6. Verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.
7. All runs of communication wiring shall be un-spliced length when that length is commercially available.
8. All communication wiring shall be labeled to indicate origination and destination data.
9. Grounding of coaxial cable shall be in accordance with NEC regulations Article on Communications Circuits, Cable and Protector Grounding.
10. Power-line carrier signal communication or transmission is not acceptable.

3.11 SENSORS AND MISCELLANEOUS FIELD DEVICES

A. Install sensors in accordance with the manufacturer’s recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Sensors used as controlled points in control loops shall be hardwired to the controller to which the controlled device is wired and in which the control loop shall reside.

D. Temperature Sensors

1. Room temperature sensors and thermostats shall be installed with back plate firmly secured to the wall framing or drywall anchors.
   a. For sensors mounted in exterior walls or columns, use a back plate insulated with foam and seal all junction box openings with mastic sealant.
   b. For sensors on exposed columns, use Wiremold or equal enclosures that are the smallest required to enclose wiring (e.g. Wiremold 400 BAC or equal) and Wiremold or equal junction boxes that are the narrowest required to enclose the temperature sensor and wiring connections (e.g. Wiremold 2348S/51 or equal). Color or raceway and boxes shall be per the architect; submit for approval prior to installation.

2. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

3. Averaging sensors shall be installed in a serpentine manner vertically across duct. Each bend shall be supported with a capillary clip. Where located in front of filters (such as mixed air sensors), access for filter removal shall be maintained.

4. Temperature sensors downstream of coils shall be located as far from the coil fins as possible, 6 inches minimum. Temperature sensors upstream of coils shall be a minimum of 6 inches away from the coil fins. No part of the sensor or its support elements or conduit shall be in contact with the coil, coil framing or coil support elements. Discharge temperature sensors on VAV boxes shall be mounted as far from the coil as possible but upstream of the first diffuser with the probe located as near as possible to the center of the duct both vertically and horizontally.

5. All pipe-mounted temperature sensors shall be installed in wells. For small piping, well shall be installed in an elbow into pipe length. Install the sensor in the well with a thermal-conducting grease or mastic. Use a closed-cell insulation patch that is integrated into the pipe insulation system to isolate the top of the well from ambient conditions but allow easy access to the sensor. Install a test plug adjacent to all wells for testing and calibration.

6. Unless otherwise noted on Drawings or Points List, temperature sensors/thermostats, humidity sensors/humidistats, CO₂ sensors, and other room wall mounted sensors shall be installed at same centerline elevation as adjacent electrical switches, 4 feet above the finished floor where there are no adjacent electrical switches, and within ADA limitations.
7. Unless otherwise noted on Drawings or Points List, install outdoor air temperature sensors on north wall where they will not be influenced by building exhaust, exfiltration, or solar insolation. Do not install near intake or exhaust air louvers.

E. Differential Pressure Sensors

1. Supply Duct Static Pressure
   a. Mount transmitter in temperature control panel near or in BAS panel to which it is wired.
   b. Low pressure port of the pressure sensor
      1) Pipe to either
         a) Building pressure (high) signal of the building static pressure transmitter.
         b) Open to a conditioned space inside the building
         c) Open to the BAS panel in which the DPT is mounted provided the panel is inside the building envelope and not in an air plenum.
   c. High-pressure port of the pressure sensor
      1) Pipe to the duct using a static pressure tip located as indicated on Drawings; if no location is indicated, locate at end of duct riser or main as far out in the system as possible but upstream of all smoke and fire dampers.
      2) Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions.

2. Building Static Pressure
   a. Mount transmitter in temperature control panel near or in BAS panel to which it is wired.
   b. Low pressure port of the pressure sensor
      1) Pipe to the ambient static pressure probe located on the outside and at high point of the building through a high-volume accumulator or otherwise protected from wind fluctuations.
   c. High-pressure port of the pressure sensor
      1) Pipe to either
         a) Behind a BAS temperature sensor cover in an interior zone (provided sensor has openings to allow ambient air to freely flow through it)
         b) Wall plate sensor
      2) Do not locate near elevators, exterior doors, atria, or (for ceiling sensor applications) near diffusers.

3. Filter Differential Pressure
   a. Install static-pressure tips upstream and downstream of filters with tips oriented in direction of flow.
   b. Mount transmitter on outside of filter housing or filter plenum in an accessible position with LCD display clearly visible. This sensor is used in lieu of an analog gauge and thus must be readily viewable.

4. High/Low Static Pressure Safeties
   a. High static
      1) Install DPS-2 on side of supply air duct in accessible location.
      2) High port shall be open to supply air duct downstream of fan.
      3) Reference low port pressure shall be that at DP location.
b. Low static
   1) Install DPS-2 inside or outside of mixed air plenum whichever is most accessible.
   2) Low port shall be open to mixed air plenum.
   3) Reference high port pressure shall be pressure on other side of mixed air plenum with the highest pressure, e.g. ambient pressure for systems with relief fans or non-powered relief, or relief air plenum for systems with return fans.

5. All pressure transducers, other than those controlling VAV boxes, shall be located where accessible for service without use of ladders or special equipment. If required, locate in field device panels and pipe to the equipment monitored or ductwork.

6. The piping to the pressure ports on all pressure transducers (both air and water) shall contain a capped test port located adjacent to the transducer.

7. Piping differential pressure transducers shall have one of the following:
   a. Five valve manifold, brass, two valves to allow removal of sensor without disrupting the hydronic system, an equalizing valve to allow the sensor to be zeroed and to prevent sensor from experiencing full static (as opposed to differential) where, and two valves used as air vents that also can be used as test plugs for calibration.
   b. For sensors using two separate sensors, install test plugs on each connection for calibration and also used as vents.

F. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current. For fans with motorized discharge dampers, adjust so that fan indicates off if damper is closed while fan is running. For pumps, adjust so that pump indicates off if valve is closed while pump is running.

G. Airflow Measuring Stations: Install per manufacturer’s recommendations for unobstructed straight length of duct both upstream and downstream of sensor, except those installations specifically designed for installation in fan inlet. For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFMS manufacturer.

H. Fluid Flow Meters: Install per manufacturer’s recommendations for unobstructed straight length of pipe both upstream and downstream of sensor. Commission per the manufacturer’s startup and commissioning recommendations. Complete all manufacturer’s startup documentation and include this in pre-functional commissioning report.

I. Actuators
   1. Type: All actuators shall be electric.
   2. Mount and link control damper actuators per manufacturer’s instructions.
   3. Dampers
      a. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage, or follow manufacturer’s instructions to achieve same effect.
      b. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
      c. Provide all mounting hardware and linkages for actuator installation.
   4. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, mount the valve so that the position indicator is visible from the floor or other readily accessible location. However, do not install valves with stem below horizontal or down. The preferred location for the valve and actuator is on lowest point in the valve train assembly for ease of access and inspection. If this is on the coil supply piping, the control valve may be located there even if schematics (and standard practice)
show valves located on the coil return piping. This comment applies to both 2-way valves and 3-way valves (which would become diverting valves rather than mixing valves in this location).

3.12 SOFTWARE INSTALLATION

A. System Configuration
   1. Thoroughly and completely configure BAS system software, supplemental software, network software etc. on OWS, POTs, and servers.

B. Point Structuring and Naming
   1. The intent of this Paragraph is to require a consistent means of naming points across the BAS. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, etc.
   2. Point Summary Table
      a. The term “Point” includes all physical I/O points, virtual points, and all application program parameters.
      b. With each schematic, provide a Point Summary Table listing
         i. Building number and abbreviation
         ii. System type
         iii. Equipment type
         iv. Point suffix
         v. Full point name (see Point Naming Convention Paragraph)
         vi. Point description
         vii. Ethernet backbone network number
         viii. Network number
         ix. Device ID
         x. Device MAC address
         xi. Object ID (object type, instance number)
         xii. Engineering units
         xiii. Device make and model number; include range of device if model number does not so identify.
         xiv. Device physical location description; include floor and column line intersection to one decimal place (for example line 6.2 and line A.3).
      c. Point Summary Table shall be provided in both hard copy and in a relational database electronic format (ODBC-compliant).
      d. Coordinate with the Owner’s representative and compile and submit a proposed Point Summary Table for review prior to any object programming or Project startup.
      e. The Point Summary Table shall be kept current throughout the duration of the Project by the Contractor as the Master List of all points for the Project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The Contractor shall deliver to the Owner the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the commissioning process.

3. Point Naming Convention
   a. All point names shall adhere to the format as established below, unless otherwise agreed to by the Owner. New categories and descriptors may be created with approval of the Owner.
   b. Format:
      2) Example: 001.HVAC.Heatplant.B-1.HWS.Temperature (sample)
<table>
<thead>
<tr>
<th>Building</th>
<th>Category</th>
<th>System</th>
<th>Equipment Tag</th>
<th>Component</th>
<th>Property</th>
<th>Typical units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELCT</td>
<td>Lighting</td>
<td>Switch</td>
<td>PHOTO</td>
<td>CB</td>
<td>Command Status</td>
<td>On/off</td>
</tr>
<tr>
<td></td>
<td>Plug</td>
<td>Switch</td>
<td>PHOTO</td>
<td>CB</td>
<td>Light</td>
<td>On/off</td>
</tr>
<tr>
<td></td>
<td>Generator</td>
<td>Switch</td>
<td>PHOTO</td>
<td>CB</td>
<td>Power</td>
<td>On/off</td>
</tr>
<tr>
<td></td>
<td>Misc</td>
<td>Switch</td>
<td>PHOTO</td>
<td>CB</td>
<td>Voltage</td>
<td>Footcandles</td>
</tr>
<tr>
<td>HVAC</td>
<td>Airhandling</td>
<td>Exhaust</td>
<td>CWS</td>
<td>CWS</td>
<td>Current</td>
<td>Volts</td>
</tr>
<tr>
<td></td>
<td>Heatplant</td>
<td>Exhaust</td>
<td>CWS</td>
<td>CWS</td>
<td>ValvePos</td>
<td>Amps</td>
</tr>
<tr>
<td></td>
<td>Coolplant</td>
<td>Exhaust</td>
<td>CWS</td>
<td>CWS</td>
<td>DamperPos</td>
<td>%open</td>
</tr>
<tr>
<td></td>
<td>Misc</td>
<td>Exhaust</td>
<td>CWS</td>
<td>CWS</td>
<td>Temperature</td>
<td>%open</td>
</tr>
<tr>
<td>PLMB</td>
<td>Domwater</td>
<td>Water</td>
<td>HWS</td>
<td>HWS</td>
<td>Humidity</td>
<td>°F</td>
</tr>
<tr>
<td></td>
<td>Air</td>
<td>Water</td>
<td>HWS</td>
<td>HWS</td>
<td>Pressure</td>
<td>%RH</td>
</tr>
<tr>
<td></td>
<td>Natgas</td>
<td>Water</td>
<td>HWS</td>
<td>HWS</td>
<td>Flow</td>
<td>Psig, &quot;H2O</td>
</tr>
<tr>
<td></td>
<td>N2</td>
<td>Water</td>
<td>HWS</td>
<td>HWS</td>
<td>Energy</td>
<td>Cfm, gpm</td>
</tr>
<tr>
<td></td>
<td>O2</td>
<td>Water</td>
<td>HWS</td>
<td>HWS</td>
<td>Speed</td>
<td>Btu</td>
</tr>
<tr>
<td></td>
<td>Irrigation</td>
<td>Water</td>
<td>CHWS</td>
<td>CHWS</td>
<td>Signal</td>
<td>%, Hz</td>
</tr>
<tr>
<td></td>
<td>Waste</td>
<td>Water</td>
<td>CHWR</td>
<td>CHWR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Misc</td>
<td>Water</td>
<td>OA</td>
<td>OA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>SA</td>
<td>SA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>RA</td>
<td>RA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>EA</td>
<td>EA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>GAS</td>
<td>GAS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>FLUID</td>
<td>FLUID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MISC</td>
<td>Weather</td>
<td>Weather</td>
<td>(from equipment schedules)</td>
<td>SWITCH</td>
<td>Command Status</td>
<td>On/off</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td>PHOTO</td>
<td>Light</td>
<td>On/off</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td>CB</td>
<td>Power</td>
<td>Footcandles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td></td>
<td>Voltage</td>
<td>Watts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td></td>
<td>Current</td>
<td>Volts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td></td>
<td>ValvePos</td>
<td>Amps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td></td>
<td>DamperPos</td>
<td>%open</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td></td>
<td>Temperature</td>
<td>%open</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td></td>
<td>Humidity</td>
<td>°F</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td></td>
<td>Pressure</td>
<td>%RH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td></td>
<td>Flow</td>
<td>Psig, &quot;H2O</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td></td>
<td>Energy</td>
<td>Cfm, gpm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td></td>
<td>Speed</td>
<td>Btu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather</td>
<td></td>
<td></td>
<td>Signal</td>
<td>%, Hz</td>
</tr>
</tbody>
</table>

4. Device Addressing Convention
   
a. BACnet network numbers and Device Object IDs shall be unique throughout the network.
b. All assignment of network numbers and Device Object IDs shall be coordinated with the Owner to ensure there are no duplicate BACnet device instance numbers.
c. Each Network number shall be unique throughout all facilities and shall be assigned in the following manner: VVVNN, where: VVV = 0-999 for BACnet Vendor ID, NN = 00 - 99 for building network.
d. Each Device Object Identifier property shall be unique throughout the system and shall be assigned in the following manner: VVVNNDD , where: VVV = number 0 to 999 for BACnet Vendor ID , NN = 00 - 99 for building network, DD = 01-99 for device address on a network.
e. Coordinate with the Owner or a designated representative to ensure that no duplicate Device Object IDs occur.
f. Alternative Device ID schemes or cross-project Device ID duplication if allowed shall be approved before Project commencement by the Owner.

5. I/O Point Physical Description
   
a. Each point associated with a hardware device shall have its BACnet long-name point description field filled out with:
      1) The device manufacturer and model number. Include range of device if model number does not so identify.
      2) For space sensors, include room number in which sensor is located.

C. Point Parameters
   
1. Provide the following minimum programming for each analog input
   a. Name
   b. Address
   c. Scanning frequency or COV threshold
   d. Engineering units
   e. Offset calibration and scaling factor for engineering units
f. High and low value reporting limits (reasonableness values), which shall prevent control logic from using shorted or open circuit values.
g. Default value to be used when the actual measured value is not reporting. This is required only for points that are transferred across the primary or secondary controlling networks and used in control programs residing in control units other than the one in which the point resides. Events causing the default value to be used shall include failure of the control unit in which the point resides or failure of any network over which the point value is transferred.

2. Provide the following minimum programming for each analog output
   a. Name
   b. Address
   c. Engineering units
   d. Offset calibration and scaling factor for engineering units
   e. Output Range
   f. Default value to be used when the normal controlling value is not reporting.

3. Provide the following minimum programming for each digital input
   a. Name
   b. Address
   c. Engineering units (on/off, open/closed, freeze/normal, etc.)
   d. Debounce time delay
   e. Message and alarm reporting as specified
   f. Reporting of each change of state, and memory storage of the time of the last change of state
   g. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.

4. Provide the following minimum programming for each digital output
   a. Name
   b. Address
   c. Output updating frequency
   d. Engineering units (on/off, open/closed, freeze/normal, etc.)
   e. Direct or Reverse action selection
   f. Minimum on-time
   g. Minimum off-time
   h. Status association with a DI and failure alarming (as applicable)
   i. Reporting of each change of state, and memory storage of the time of the last change of state.
   j. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
   k. Default value to be used when the normal controlling value is not reporting.

D. Site-Specific Application Programming
   1. All site-specific application programming shall be written in a manner that will ensure programming quality and uniformity. Contractor shall ensure:
      a. Programs are developed by one programmer, or a small group of programmers with rigid programming standards, to ensure a uniform style.
      b. Programs for like functions are identical, to reduce debugging time and to ease maintainability.
      c. Programs are thoroughly debugged before they are installed in the field.
   2. Massage and tune application programming for a fully functioning system. It is the Contractor’s responsibility to request clarification on sequences of operation that require such clarification.
3. All site-specific programming shall be fully documented and submitted for review and approval
   a. Prior to downloading into the panel (see Submittal Package 2, Paragraph 1.8.)
   b. At the completion of functional performance testing, and
   c. At the end of the warranty period (see Warranty Maintenance,

4. All programming, graphics and data files must be maintained in a logical system of directories with self-explanatory file names. All files developed for the Project will be the property of the Owner and shall remain on the workstations/servers at the completion of the Project.

E. Graphic Screens

1. All site-specific graphics shall be developed in a manner that will ensure graphic display quality and uniformity among the various systems.

2. Schematics of MEP systems
   a. Schematics shall be 2-D or 3-D and shall be based substantially on the schematics provided on Drawings.
   b. All relevant I/O points and setpoints being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Include appropriate engineering units for each displayed point value. Verbose names (English language descriptors) shall be included for each point on all graphics; this may be accomplished by the use of a pop-up window accessed by selecting the displayed point with the mouse.
   c. Animation or equipment graphic color changes shall be used to indicate on/off status of mechanical components.
   d. Indicate all adjustable setpoints and setpoint high and low limits (for automatically reset setpoints), on the applicable system schematic graphic or, if space does not allow, on a supplemental linked-setpoint screen.

3. Displays shall show all points relevant to the operation of the system, including setpoints.

4. The current value and point name of every I/O point and setpoint shall be shown on at least one graphic and in its appropriate physical location relative to building and mechanical systems.

5. Show weather conditions (local building outside air temperature and humidity) in the upper left-hand corner of every graphic.

6. CAD Files: The contract document drawings will be made available to the Contractor in AutoCAD format upon request for use in developing backgrounds for specified graphic screens, such as floor plans and schematics. However, the Owner does not guarantee the suitability of these drawings for the Contractor’s purpose.

7. Provide graphics for the following as a minimum
   a. Building homepage: Background shall be a building footprint, approximately to scale, oriented as shown on the campus homepage. Include links to each floor and mechanical room/area, and to summary graphics described below. Include real-time site utility data such as electric meterbuilding electrical demand, domestic cold-water flow, and natural gas demand shown roughly on the map where the utilities connect to the site.
   b. Electricity demand limiting
      1) Demand limit. Include entries for sliding window interval and a table of On-Peak or Partial-Peak demand time periods with three adjustable demand level limits for each and adjustable deadband.
      2) Electricity demand calculation. For each month, show actual peak kW and kWh for each time-of-day rate period. Show side-by-side as month-this-year and month-last-year, and month-to-date and year-to-date data.
   c. Each occupied floor plan, to scale
1) HVAC: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints. The colors shall be updated dynamically as a zone’s actual comfort condition changes. In each zone, provide links to associated terminal equipment.

2) If multiple floor plans are necessary to show all areas, provide a graphic building key plan. Use elevation views or plan views as necessary to graphically indicate the location of all of the larger scale floor plans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens.

d. Each equipment floor/area plan: To scale, with links to graphics of all BAS controlled/monitored equipment.

e. Each air handler and fan-coil: Provide link to associated HW and CHW plants where applicable.

f. Each trim & respond reset: Next to the display of the setpoint that is being reset, include a link to page showing all trim & respond points (see Guideline 36) plus the current number of requests, current setpoint, and status indicator point with values “trimming,” “responding,” or “holding.” Include a graph of the setpoint trend for the last 24 hours. Trim & respond points shall be adjustable from the graphic except for the associated device.

g. Each zone terminal:

1) Provide link to associated air handling unit where applicable and to floor plan where terminal is located.

2) Include supply air temperature from AHU serving terminal unit.

3) Include a non-editable graphic (picture) showing the design airflow setpoints from the design drawings adjacent to the editable airflows setpoints. The intent is that the original setpoints be retained over time despite “temporary” adjustments that may be made over the years.

h. Electrical power monitoring system: Show a schematic of the electrical system based on one-line diagrams with meter current kW reading and month-to-date kWh shown in actual locations. Power flow shall change on the diagram (by changing line color or width) to show which power line is active.

i. Central plant equipment including chilled water system, cooling tower system, hot water system, steam system, generators, etc.: The flow path shall change on the diagram (by changing piping line color or width) to show which piping has active flow into each ASHP, ASHP, tower, etc. as valve positions change.

j. Summary graphics: Provide a single text-based page (or as few as possible) for each of the following summary screens showing key variables listed in columns for all listed equipment. Include hyperlinks to each zone imbedded in the zone tag:

1) Air handling units: operating mode; on/off status; supply air temperature; supply air temperature setpoint; fan speed; duct static pressure; duct static pressure setpoint; outdoor air and return air damper position; coil valve positions; etc. (all key operating variables); Cooling CHWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Heating HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier (if HW coil)

2) VAV Zone terminal units: operating mode; airflow rate; airflow rate setpoint; zone temperature; active heating setpoint; active cooling setpoint; damper position; HW valve position (reheat boxes); supply air temperature (reheat boxes); supply air temperature setpoint (reheat boxes); CO2 concentration and CO2 loop output (where applicable); Fan start/stop command, speed, and status (fan-powered); Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Cooling SAT Reset current
requests, cumulative %-request-hours, and request Importance Multiplier; Heating HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier (HW reheat); Heating Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier (dual duct); Heating SAT Reset current requests, cumulative %-request-hours, and request Importance Multiplier (dual duct).

3) Laboratory VAV Zone terminal units: operating mode; airflow rate; airflow rate setpoint; zone temperature; active heating setpoint; active cooling setpoint; damper position; HW valve position; CHW valve position; supply air temperature; supply air temperature setpoint; Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Cooling SAT Reset current requests, cumulative %-request-hours, and request Importance Multiplier; HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier; CHWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier.

4) Laboratory Air Systems: operating mode; supply airflow rate, airflow rate setpoint, damper position, Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; general exhaust airflow rate, airflow rate setpoint, damper position, Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; hood exhaust airflow rate, airflow rate setpoint, damper position, Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier.

5) Fan-coil units: operating mode; zone temperature; active heating setpoint; active cooling setpoint; supply air temperature; supply air temperature setpoint (where applicable); fan status; fan speed (where applicable); HW/CHW valve position; Cooling CHWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Heating HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier.

6) Lab Zone terminal units: operating mode; supply airflow rate; supply airflow rate setpoint; zone temperature; active heating setpoint; active cooling setpoint; supply air temperature; supply air temperature setpoint; fume hood status; exhaust airflow rate; Supply Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Exhaust Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Cooling SAT Reset current requests, cumulative %-request-hours, and request Importance Multiplier; CHWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier; HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier.

7) Electrical meters and switches: Volts, current, kW, switch positions.

k. For all equipment with runtime alarms specified, show on graphic adjacent to equipment the current runtime, alarm setpoint (adjustable), alarm light, date of last runtime counter reset, and alarm reset/acknowledge button which resets the runtime counter.

l. For all equipment with lead/lag or lead/standby operation specified, show on graphic adjacent to equipment the current lead/lag order and manual buttons or switches to allow manual lead switching by the operator per Paragraph 3.13B.5.

m. For all controlled points used in control loops, show the setpoint adjacent to the current value of the controlled point.

n. All other BAS controlled/monitored equipment.

o. On all system graphics, include a “note” block that allows users to enter comments relevant to system operation.
p. All equipment shall be identified on the graphic screen by the unit tag as scheduled on the drawings.

F. Alarm Configuration

1. Program alarms and alarm levels per Sequence of Operations.
2. Each programmed alarm shall appear on the alarm log screen and shall be resettable or acknowledged from those screens. Equipment failure alarms shall be displayed on the graphic system schematic screen for the system that the alarm is associated with (for example, fan alarm shall be shown on graphic air handling system schematic screen). For all graphic screens, display values that are in a Level 1 or 2 condition in a red color, Level 3 and higher alarm condition in a blue color, and normal (no alarm) condition in a neutral color (black or white).

3. For initial setup, Contractor shall configure alarms as follows:

<table>
<thead>
<tr>
<th></th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criticality</td>
<td>Critical</td>
<td>Not Critical</td>
<td>Not Critical</td>
<td>Not Critical</td>
</tr>
<tr>
<td>Acknowledgement</td>
<td>Required</td>
<td>Required</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>Acknowledgement of Return to Normal</td>
<td>Not Required</td>
<td>Not Required</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>Email to building engineer(s)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Pop-up dialog box on OWS</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Remove from alarm log</td>
<td>After Acknowledged</td>
<td>After Acknowledged</td>
<td>After 2 weeks</td>
<td>After 2 weeks</td>
</tr>
</tbody>
</table>

4. At the end of commissioning and then again at the end of the warranty period, fully synchronize the database on this POT with that on the CSS.

3.13 SEQUENCES OF OPERATION

A. Sequences herein reference ASHRAE Guideline 36-2018, possibly followed by exceptions or additions where indicated. Guideline 36 sequences are not repeated herein for brevity and to make exceptions/revisions very clear. However, the final as-built sequences of operation (see Paragraph 1.9B.1.j and 1.1A.1.a.1)a(1)) shall include all installed sequences verbatim from Guideline 36.

B. General

1. Fully comply with ASHRAE Guideline 36-2018 Section 5.1 General.
2. Contractor shall review sequences prior to programming and suggest modifications where required to achieve the design intent. Contractor may also suggest modifications to improve performance and stability or to simplify or reorganize logic in a manner that provides equal or better performance. Proposed changes in sequences shall be included as a part of Submittal Package 2.
3. Include costs for minor program modifications if required to provide proper performance of the system.
4. Minimum speed setpoints for all VFD-driven equipment shall be determined in accordance with Paragraph 3.15E.7.
5. Equipment Staging and Rotation
   a. Parallel devices shall be lead/lag or lead/standby rotated to maintain even wear.
   b. Two runtime points shall be defined for each device:
      1) Lifetime Runtime: The cumulative runtime of the device since device start-up. This point shall not be readily resettable by operators.
      2) Staging Runtime: An operator resettable runtime point that stores cumulative runtime since the last operator reset.
c. Lead/lag devices: Unless otherwise noted, parallel staged devices (such as CHW pumps and cooling towers) shall be lead/lag alternated when more than one is off or more than one is on so that the device with the most operating hours as determined by Staging Runtime is made the last stage device and the one with the least number of hours is made the lead stage device.

This strategy effectively makes it such that devices are not “hot swapped”, e.g. a pump would not be started and another stopped during operation just for runtime equalization.

For example, assume there are two devices and only one is on, but the operating device has exceeded the run hours of the disabled device. The devices will not rotate positions until either a stage up or down occurs. If the plant stages up, then both devices will be on and lead/lag position will switch; when the plant next stages down, the former lead device with more run hours will then turn off.

Expanding further, for a plant with three devices, if all three are off or all are on, the staging order will simply be based on run hours from lowest to highest. If two devices are on, the one with more hours will be set to be stage 2 while the other is set to stage 1; this may be the reverse of the operating order when the devices were started. If two devices are off, the one with the more hours will be set to be stage 3 while the other is set to stage 2; this may be the reverse of the operating order when the devices were stopped.

Example with three pumps:
1. P-1 (1000 hours), 2 (950 hours), and 3 (900 hours) are all off. Staging logic makes lead/lag order: 3, 2, 1
2. P-3 starts. Logic does not change its order since it is on by itself.
3. P-3 runs for 51 hours. Since it is on and others off, the lead/lag order does not change. It can run this way indefinitely and the order does not change.
4. There is then a stage-up command. P-2 (the next in lead/lag order) is started. So both P-2 and P-3 are on. P-3 now as more run hours than P-2. So the Lead/lag order changes to: 2, 3, 1.
5. These two pumps run another 51 hours. Run times are P-1 (1000 hours), P-2 (1001) and P-3 (1002). No changes are made to lead/lag order because P-1 is off alone.
6. There is a stage down command. P-2 is now lead so it stays on. P-3 is shut off. The order for the two off pumps is now adjusted because P-1 has fewest run hours. lead/lag order is now: 2, 1, 3
7. P-2 runs for 100 more hours. It now has the longest runtime, but order does not change since it is on alone. Order is still 2, 1, 3
8. There is a stage down or plant-off command. P-2 shuts off. Run times are P-1 (1000 hours), P-2 (1101) and P-3 (1002). Since all are off, order is switched to: 1, 3, 2

Example with three pumps:
1. P-1 (1000 hours), 2 (950 hours), and 3 (900 hours) are all off. Staging logic makes lead/lag order: 3, 2, 1
2. P-3 starts. Logic does not change its order since it is on by itself.
3. P-3 runs for 51 hours. Since it is on and others off, the lead/lag order does not change. It can run this way indefinitely and the order does not change.
4. There is then a stage-up command. P-2 (the next in lead/lag order) is started. So both P-2 and P-3 are on. P-3 now as more run hours than P-2. So the Lead/lag order changes to: 2, 3, 1.
5. These two pumps run another 51 hours. Run times are P-1 (1000 hours), P-2 (1001) and P-3 (1002). No changes are made to lead/lag order because P-1 is off alone.
6. There is a stage down command. P-2 is now lead so it stays on. P-3 is shut off. The order for the two off pumps is now adjusted because P-1 has fewest run hours. lead/lag order is now: 2, 1, 3
7. P-2 runs for 100 more hours. It now has the longest runtime, but order does not change since it is on alone. Order is still 2, 1, 3
8. There is a stage down or plant-off command. P-2 shuts off. Run times are P-1 (1000 hours), P-2 (1101) and P-3 (1002). Since all are off, order is switched to: 1, 3, 2

Example with three pumps:
2) If devices run continuously, lead/standby positions shall switch at an adjustable frequency (e.g. every 14 days) based on Staging Runtime; standby device shall first be started and proven on before former lead device is changed to standby and shut off.

a) Variable speed pumps shall have a deceleration rate of 1 Hz/second or slower set in BAS logic when disabled to prevent nuisance trips of operating devices (e.g. ASHPs).

e. Exceptions to Lead/lag and Lead/standby rotation

1) Operators with appropriate access level shall be able to manually command staging order via software points, but not overriding the In Alarm or Hand Operation logic below.

a) Faulted Devices: A faulted device is any device commanded to run that is either not running or unable to perform its required duty. If an operating device has any fault condition described subsequently, a Level 2 alarm shall be generated and a response shall be triggered as defined below.

(1) Fans and Pumps

(a) Status point not matching its on/off point for 3 seconds after a time delay of 15 seconds when device is commanded on.

(1) ASHPs

(a) Shutdown alarm condition either through network or hardwired alarm contact, or
(b) ASHP is manually shut off as indicated by the status of the Local/Auto switch from ASHP gateway, or
(c) ASHP status remains off 5 minutes after command to start, or
(d) If provided, CHW isolation valve feedback indicates valve is not open 90 seconds after device is commanded open, or
(e) If provided, CW isolation valve feedback indicates valve is not open 90 seconds after device is commanded open.
(f) For 15 minutes chilled water return temperature has been at least 5°F above the CHWST setpoint, and delta-T across the ASHP, as determined based on the difference between chilled water return temperature and chilled water supply temperature measured at the ASHP (i.e. not common CHWST), has been less than 3°F.

b) Upon identification of a fault condition:

(1) For fans and pumps:

(a) The next commanded OFF device in the staging order, Device “B”, shall be commanded ON while alarming Device “A” remains commanded ON.
(b) If Device B fails to prove status (i.e. it also goes into alarm), it shall remain commanded on and the preceding step shall be repeated until the quantity of devices called for by the lead/lag logic have proven on.
(c) When either the required number of devices proves on or all devices are commanded on, set alarming devices
to the last positions in the lead/lag staging order sequenced reverse chronologically (i.e. the device that alarmed most recently is sent to last position).

(d) Staging order of non-alarming devices shall follow the even wear logic. A device in alarm can only automatically move up in the staging order if another device goes into alarm.

(e) Devices in alarm shall run if so called for by the lead/lag staging order and present stage.

(2) For ASHP:

(a) The next commanded OFF device in the staging order, Device “B”, shall be commanded ON while alarming Device “A” is commanded OFF and set to the last position in the lead/lag staging order.

(b) If Device B fails to prove status (i.e. it also goes into alarm), repeat the preceding step until the quantity of devices called for by the lead/lag logic have proven on.

(c) Staging order of non-alarming devices shall follow the even wear logic. A device in alarm can only automatically move up in the staging order if another device goes into alarm.

(d) Devices in alarm shall run if so called for by the lead/lag staging order and present stage.

2) Hand Operation: If a device is on in Hand (e.g., via an HOA switch or local control of VFD), the device shall be set to the lead device and a Level 4 alarm shall be generated. The device will remain as lead until the alarm is reset by the operator. Hand operation is determined by:

a) Fans and Pumps

(1) Status point not matching its on/off point for 15 seconds when device is commanded off.

6. Occupancy Status

a. Occupancy status of all spaces shall be via the Lighting Control BACnet interface.

b. In case of the network connection with the Lighting Controls is lost:

1) For lab zones, occupancy status shall default to “occupied” (for safety reasons)

2) For all other zones, occupancy status shall default to “occupied” if the Zone Group is in Occupied Mode and “unoccupied” for any other Zone Group Mode.

7. VAV Box Controllable Minimum

a. This section is used to determine the lowest possible VAV box airflow setpoint (other than zero) allowed by the controls (Vm) used in VAV box control sequences. The minimums shall be stored as software points that may be adjusted by the user but need not be adjustable via the graphical user interface.

b. Option 1: If the VAV box controller can control to 0.004” per Paragraph 2.9I.5.c., the minimum setpoint Vm shall be determined from the table below if the VAV box manufacturer is listed:

<table>
<thead>
<tr>
<th>Inlet</th>
<th>Titus</th>
<th>Krueger</th>
<th>Price</th>
<th>MetalAire High Gain</th>
<th>ETI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>
c. Option 2: The minimum setpoint $V_m$ shall be determined per Guideline 36.

8. Lab Air Valve Controllable Minimum

a. This section is used to determine the lowest possible valve airflow setpoint allowed by the controls used in lab control sequences. The minimums shall be stored as software points that may be adjusted by the user but need not be adjustable via the graphical user interface. If not listed, obtain data from manufacturer with review and approval by Engineer.

b. The valve controllable minimum shall be determined from the table below if the valve manufacturer is listed:

<table>
<thead>
<tr>
<th>Inlet</th>
<th>Titus</th>
<th>Krueger</th>
<th>Price</th>
<th>MetalAire High Gain</th>
<th>ETI</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>30</td>
<td>35</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>55</td>
<td>60</td>
<td>55</td>
<td>50</td>
<td>55</td>
</tr>
<tr>
<td>10</td>
<td>90</td>
<td>90</td>
<td>95</td>
<td>85</td>
<td>90</td>
</tr>
<tr>
<td>12</td>
<td>120</td>
<td>130</td>
<td>135</td>
<td>110</td>
<td>130</td>
</tr>
<tr>
<td>14</td>
<td>190</td>
<td>175</td>
<td>195</td>
<td>155</td>
<td>180</td>
</tr>
<tr>
<td>16</td>
<td>245</td>
<td>230</td>
<td>260</td>
<td>210</td>
<td>235</td>
</tr>
<tr>
<td>24x16</td>
<td>455</td>
<td>445</td>
<td>490</td>
<td>N/A</td>
<td>415</td>
</tr>
</tbody>
</table>

C. Electricity Demand Limiting

1. Base demand on power to entire building based on monitored Division 26 power meter.
2. Sliding Window: The demand control function shall utilize a sliding window method selectable in increments of one minute, up to 60 minutes, 15-minute default.
3. Demand Levels: Demand time periods shall be set up as per utility rate schedule. For each On-Peak or Partial-Peak period, three demand level limits can be defined. When the measured demand exceeds the limit, the Demand Limit Level switch for that level shall be set; when demand is less than 10% (adjustable) below the limit for a minimum of 15 minutes, and the time is no longer within the On-Peak or Partial-Peak window, the switch shall be reset. These levels are used at the zone level (see Zone Control sequences) to shed demand.
4. In addition to setpoint reset logic triggered by Demand Levels as described below, include Demand Shed commands to the lighting control system via BACnet interface for each Demand Level. The response to each Demand Shed command shall be programmed into the lighting control system under Division 26.

D. Zones

1. Fully comply with ASHRAE Guideline 36-2018 Section 5.2 Generic Ventilation Zones.
   a. Use Title 24 for ventilation logic.
      1) Add the following to 5.2.1.4.2
c. If no value is entered in VAV box schedules for Occupied Minimum Airflow Setpoint (Vmin), Vmin shall be set equal Zone-Abs-OA-min

b. Fully implement Time Averaged Ventilation (TAV) 5.2.2 and use it when VAV minimum, Vmin*, is below the lowest allowed by the controls (Vm).

2. Fully comply with ASHRAE Guideline 36-2018 Section 5.3 Generic Thermal Zones.
   a. Default setpoints:

<table>
<thead>
<tr>
<th>Zone type</th>
<th>Occupied</th>
<th>Unoccupied</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heat</td>
<td>Cool</td>
</tr>
<tr>
<td>VAV exterior</td>
<td>70°F</td>
<td>75°F</td>
</tr>
<tr>
<td>VAV interior</td>
<td>70°F</td>
<td>75°F</td>
</tr>
<tr>
<td>Electrical and mechanical</td>
<td>60°F</td>
<td>85°F</td>
</tr>
<tr>
<td>IDF/MDF</td>
<td>60°F</td>
<td>78°F</td>
</tr>
<tr>
<td>Labs</td>
<td>70°F</td>
<td>75°F</td>
</tr>
</tbody>
</table>

E. Zone Groups
   1. Fully comply with ASHRAE Guideline 36-2018 Section 5.4 Zone Groups.
   2. Consult with Owner for all schedules. Use the following initial schedule:
      a. Weekday: 7am to 7pm
      b. SAT: 9am to 2pm
      c. SUN: off
      d. Holiday: off

   3. Exception: the lab exhaust must run 24/7 including unoccupied times to ensure safety in the labs.

F. Laboratory Emergency Pressure Relief Dampers
   1. The intent of these dampers is to prevent the labs from becoming too negative in the event of a power loss. The exhaust fans are on emergency power and are still able to run in the event of a power loss.
   2. These dampers will have spring return actuators that return to a fail-safe position of open when power is lost.
   3. By opening, this will break the negative pressure of the room.
   4. DDC contractor to provide 24V power to these dampers. Select damper such that an input of 0V will command the damper to closed.
   5. No other monitoring of these devices is required.

G. Four-Pipe VAV Zone
   1. Design setpoints shall be as scheduled on plans:
      a. Supply air valve
         1) Maximum airflow setpoint (Vmax)
         2) Minimum occupied airflow setpoint (Vmin-occ)
         3) Minimum unoccupied airflow setpoint (Vmin-unocc)
         4) Design heating coil leaving air temperature (SATmax)
         5) Design demand control minimum

   2. Controllable minimum. Where there is more than one terminal, rates shall be added together.
   3. Supply air system
      a. Supply airflow and temperature control logic is depicted schematically in the figure below and described in the following sections.
b. When the zone served by the system is in the Cooling Mode
   1) Supply air temperature setpoint shall be reset from SATmin at 50% Cooling Loop output and above proportionally up to Deadband SAT Setpoint at 0% Cooling Loop output.
   2) Airflow setpoint shall be reset from Vmax at 100% Cooling Loop down to Vmin* at 50% Cooling Loop output and below.

c. When the zone served by the system is in the Deadband Mode
   1) Deadband SAT Setpoint shall be the average of current cooling and heating space temperature setpoints.
   2) Airflow setpoint shall be Vmin*.

d. When the zone is in the Heating Mode
   1) Supply air temperature setpoint shall be reset from Deadband SATmin at 0% Heating Loop output proportionally up to SATmax at 50% Heating Loop output and above.
   2) If the supply air temperature is greater than the room temperature plus 5°F, the airflow setpoint shall be reset from Vmin* at 50% Heating Loop output and below proportionally up to Vmax at 100% Heating Loop output.

e. The hot water and chilled water valves shall be modulated in sequence using P+I loop to maintain the discharge temperature at setpoint. (Directly controlling valves off zone temperature PID loop is not acceptable.)

f. The VAV damper shall be modulated to maintain the measured airflow at setpoint.

4. Demand Control Ventilation
   a. For zones with space co2 sensors, use the scheduled demand control ventilation rate rather than the ventilation minimum.
   b. Record the ambient space CO2 to use as a baseline.
   c. When the space CO2 rises 600 ppm (adj) above ambient, begin resetting supply cfm linearly up to the ventilation minimum.

5. System Requests
   a. Cooling SAT Reset Requests
1) If the CHW valve is less than 90%, send 0 Requests
2) If the CHW valve is greater than 95%, send 1 Request
3) IF the zone cooling valve is full open, AND the zone temperature exceeds the zone’s cooling setpoint by 3°F for 5 minutes, send 2 Requests
4) IF zone cooling valve is full open, AND the zone temperature exceeds the zone’s cooling setpoint by 5°F for 15 minutes, send 3 Requests

b. HHW Temp Reset Requests
   1) If the HHW valve is less than 90%, send 0 Requests
   2) If the HHW valve is greater than 95%, send 1 Request
   3) IF the zone heating valve is full open, AND the zone temperature exceeds the zone’s heating setpoint by 3°F for 5 minutes, send 2 Requests
   4) IF zone heating valve is full open, AND the zone temperature exceeds the zone’s heating setpoint by 5°F for 15 minutes, send 3 Requests

c. Supply Static Pressure Reset Requests (Feedback loop type valves; separately include all exhaust and supply air valves in zone)
   1) If the Damper Loop is less than 85%, send 0 requests
   2) If the Damper Loop is greater than 95%, send 1 request
   3) If the measured airflow is less than 85% of setpoint for 30 seconds, send 3 requests

H. Return Air Exhaust Damper (Floors 1 and 2)
   1. General
      a. Floors one and two have return air dampers that control to CFM.
      b. These dampers on connected to the return air duct associated with standard VAVs not with labs.
      c. These dampers are to regulate the return air from these non-lab spaces in a pressure independent manner similar to a VAV but with no temperature control.

   2. Flow control:
      a. Active airflow setpoint at the return air dampers to be a sum of the associated VAV – offset.
      b. The necessary offset for each zone group is to be field determined by the air balancer to maintain the VAV zone group positive to the surrounding spaces at +.1” positive (adj).

I. Laboratory Four-Pipe VAV Zone
   1. See Paragraph 3.13D for setpoints, loops, control modes, alarms, etc.
   2. Design setpoints shall be as scheduled on plans:
      a. Room Pressurization
         1) Pressurization offset (Voffset). Initial pressurization offsets shall be shown on schedules. For all lab zones, final pressurization offsets shall be determined as specified under Section 230593 Testing, Adjusting, and Balancing.
      b. Supply air valve
         1) Maximum airflow setpoint (Vmax)
         2) Minimum occupied airflow setpoint (Vmin-occ)
         3) Minimum unoccupied airflow setpoint (Vmin-unocc)
         4) Design heating coil leaving air temperature (SATmax)
         5) Design cooling coil leaving air temperature (SATmin)
c. Hood exhaust air valve. Where there is more than one hood (see plan for quantity), rates shall be added together.
   1) Maximum airflow setpoint (Vhex-max)
   2) Minimum airflow setpoint (Vhex-min)

d. General exhaust air valve. Where there is more than one GEX (see plan for quantity), rates shall be added together.
   1) Maximum airflow setpoint (Vgex-max)
   2) Minimum airflow setpoint (Vgex-min)

3. Controllable minimum. Where there is more than one terminal, rates shall be added together.
   a. For slow VAV zones, supply VAV box controllable minimum (Vctrl-min) and general exhaust VAV box controllable minimum (Vgex-ctrl-min) shall be determined in accordance with Paragraph 3.13B.5.
   b. For fast VAV zones, supply air valve controllable minimum (Vctrl-min) and general exhaust air valve controllable minimum (Vgex-ctrl-min) shall be determined in accordance with Paragraph 3.13B.8.

4. The actual minimum Vmin* shall be equal to the larger of:
   a. Exhaust makeup air rate calculated below, Vmu
   b. Minimum ventilation rate (Vvent) equal to
      1) If the zone is unoccupied as indicated by its occupancy sensor and the lab is scheduled to be unoccupied, Vmin-unocc.
      2) Otherwise, Vmin-occ
   c. Vctrl-min

5. Supply air system
   a. Supply airflow and temperature control logic is depicted schematically in the figure below and described in the following sections.

   b. When the zone served by the system is in the Cooling Mode
1) Supply air temperature setpoint shall be reset from SATmin at 50% Cooling Loop output and above proportionally up to Deadband SAT Setpoint at 0% Cooling Loop output.
2) Airflow setpoint shall be reset from Vmax at 100% Cooling Loop down to Vmin* at 50% Cooling Loop output and below.

c. When the zone served by the system is in the Deadband Mode
1) Deadband SAT Setpoint shall be the average of current cooling and heating space temperature setpoints.
2) Airflow setpoint shall be Vmin*.

d. When the zone is in the Heating Mode
1) Supply air temperature setpoint shall be reset from Deadband SATmin at 0% Heating Loop output proportionally up to SATmax at 50% Heating Loop output and above.
2) If the supply air temperature is greater than the room temperature plus 5ºF, the airflow setpoint shall be reset from Vmin* at 50% Heating Loop output and below proportionally up to Vmax at 100% Heating Loop output.

e. The hot water and chilled water valves shall be modulated in sequence using P+I loop to maintain the discharge temperature at setpoint. (Directly controlling valves off zone temperature PID loop is not acceptable.)
f. The VAV damper shall be modulated to maintain the measured airflow at setpoint.

6. Pressurization control
a. Sign conventions: All airflows have a positive sign, except for the room offset airflow which may be positive (for positively pressurized lab) or negative (for negatively pressurized lab).
b. Vgex-step shall be equal to Vgex-ctrl-min
1) Exception: Vgex-step shall equal 0 if the zone thermal load does not demand an increase in airflow (i.e. Cooling Loop Output < 50% and Heating Loop Output < 50% for 4-pipe zone) and the following has been less than or equal to 0 for 30 seconds or more:
   a) The larger of Vvent and Vctrl-min, minus the sum of:
      (1) Sum of fume hood exhaust valve(s) airflow feedback
      (2) Other exhaust airflows, e.g. canopy/cabinet/snorkel etc. (if applicable, see plans for quantity and airflows)
      (3) Voffset

c. The make-up airflow demand (Vmu) is equal to the sum of:
1) Sum of fume hood exhaust valve(s) airflow feedback
2) Vgex-step
3) Other exhaust airflows, e.g. canopy/cabinet/snorkel etc. (if applicable, see plans for quantity and airflows)
4) Voffset
d. The general exhaust valve setpoint shall equal 0 when Vgex-step is equal 0, otherwise it shall equal the sum of:
1) Supply valve feedback airflow minus Vmu
2) The general exhaust valve controllable minimum airflow, Vgex-ctrl-min

7. Alarms
a. Airflow alarm
1) If the airflow feedback from any valve is 15% above or below setpoint for 5 minutes, generate a Level 3 alarm.

2) If the airflow feedback from any valve is 30% above or below setpoint for 5 minutes, generate a Level 2 alarm.

b. Room pressurization polarity alarm

1) Generate a Level 2 alarm if the airflow offset has incorrect polarity for 5 minutes based on sum of exhaust feedback signals and supply feedback signal:
   a) For a room with negative offset, if exhaust minus supply < 0
   b) For a room with positive offset, if exhaust minus supply > 0

c. Room low supply rate alarm

1) If the sum of exhaust feedback signals exceeds supply feedback signal by more than 4 times (adjustable) the offset for 1 minute:
   a) Generate a Level 1 alarm (high level due to problems exiting)
   b) All fume hood sashes in room shall be commanded closed.
   c) All fume hood exhaust setpoints shall be reduced to a fixed percentage of the maximum hood rates; this percentage shall be determined as specified in Section 230593 Testing, Adjusting and Balancing.

d. Low supply air temperature

1) If HHW plant is proven on and the supply air temperature is 15°F less than setpoint for 10 minutes, generate a Level 3 alarm.

2) If HHW plant is proven on and the supply air temperature is 30°F less than setpoint for 10 minutes, generate a Level 2 alarm.

e. High supply air temperature

1) If ASHP plant is proven on and the supply air temperature is 10°F more than setpoint for 10 minutes, generate a Level 3 alarm.

2) If ASHP plant is proven on and the supply air temperature is 20°F more than setpoint for 10 minutes, generate a Level 2 alarm.

f. Fume hood

1) Fume hood alarm: Level 2

2) If average sash height (interpolated based on average cfm feedback through the hood and design maximum and minimum setpoints) during the last 24 hours is greater than 50% (adjustable), generate a Level 4 alarm

8. Testing/Commissioning Overrides: Provide software points that interlock to a system level point to

a. Force supply airflow setpoint to zero
b. Force supply airflow setpoint to Vmax
c. Force supply airflow setpoint to Vmin
d. Force supply damper full closed/open
e. Force heating valve to closed
f. Force cooling valve to closed
g. Force hood exhaust airflow setpoint to Vhex-max
h. Force hood exhaust airflow setpoint to Vhex-min
i. Force general exhaust airflow setpoint to Vgex-max
j. Force general exhaust airflow setpoint to Vgex-min
k. Reset request-hours accumulator point to zero (provide one point for each reset type listed below)

9. System Requests
a. Cooling SAT Reset Requests
   1) If the CHW valve is less than 90%, send 0 Requests
   2) If the CHW valve is greater than 95%, send 1 Request
   3) IF the zone cooling valve is full open, AND the zone temperature exceeds the zone’s cooling setpoint by 3°F for 5 minutes, send 2 Requests
   4) IF zone cooling valve is full open, AND the zone temperature exceeds the zone’s cooling setpoint by 5°F for 15 minutes, send 3 Requests

b. HHW Temp Reset Requests
   1) If the HHW valve is less than 90%, send 0 Requests
   2) If the HHW valve is greater than 95%, send 1 Request
   3) IF the zone heating valve is full open, AND the zone temperature exceeds the zone’s heating setpoint by 3°F for 5 minutes, send 2 Requests
   4) IF zone heating valve is full open, AND the zone temperature exceeds the zone’s heating setpoint by 5°F for 15 minutes, send 3 Requests

c. Supply Static Pressure Reset Requests (Feedback loop type valves; separately include all exhaust and supply air valves in zone)
   1) If the Damper Loop is less than 85%, send 0 requests
   2) If the Damper Loop is greater than 95%, send 1 request
   3) If the measured airflow is less than 85% of setpoint for 30 seconds, send 3 requests

J. Fume Hood Lab Exhaust Air Valve
   1. General
      a. Lab exhaust air valves for fume hoods control airflow to maintain face velocity at the fume hood.
      b. Lab exhaust air valves maintain face velocity at all times regardless of zone occupancy status.
      c. At the end of the occupied period command all automatic sash closers to shut in every classroom. Send alarm at front end if any sash cannot meet commanded state.

   2. Sash Position Sensor
      a. A sash position sensor mounted on the fume hood shall provide a signal that is linearly proportional to the actual sash position.

   3. Face Velocity Control
      a. The fume hood controller shall continually determine the total fume hood open area by monitoring the fume hood sash position via the sash sensor as well as taking account of any fume hood fixed open areas and/or bypass openings.
      b. The fume hood controller shall calculate the required fume hood exhaust airflow necessary to maintain the average face velocity setpoint over the total open area.

   4. Airflow Control
      a. The Fume Hood Air Valve damper shall be modulated by a control loop to maintain the measured airflow at the active setpoint Vspt_fumehood.
      b. Fume hood controller shall ensure that the required fume hood exhaust to maintain the average face velocity setpoint is always maintained independently of any variations in exhaust system static pressure or any laboratory room conditions such as the ventilation airflow or room static pressure that could otherwise affect the fume hood exhaust airflow

   5. Operator Display Panel
a. The fume hood controller shall also interface to an operator display panel (ODP) at the designated measurement location on the front of the fume hood.

b. The ODP shall provide a continuous digital display of the average fume hood face velocity at all times. The fume hood face velocity display shall be the true average face velocity as calculated by the fume hood controller based upon the actual measured fume hood exhaust airflow and the total fume hood total open area.

c. The ODP shall also include separate colored lights that shall illuminate to indicate fume hood operations status:
   1) Green- Proper face velocity
   2) Yellow- Marginal face velocity
   3) Red- Face Velocity Alarm Conditions
   4) The ODP shall also contain an audible alarm device that responds to face velocity alarm conditions and the ODP digital display shall change to “low face velocity” or “high face velocity” appropriate to the alarm condition.
   5) A silence push button at the ODP shall allow the user to silence the audible alarm which shall then remain silent until a subsequent face velocity alarm occurs.

6. Purge Mode

a. The ODP shall also provide an emergency purge pushbutton which shall allow a user to increase fume hood exhaust airflow to the maximum amount for a designated period of time as required by lab safety standards.

b. The initial setting for the emergency purge time shall be 1 minute.

c. After the designate emergency purge time has expired, the fume hood exhaust shall automatically reset to a lower level to prevent excessive demand on the exhaust system.

d. Emergency purge mode shall be cancellable at any time by depressing the emergency purge button a second time.

e. The ODP shall sound its audible alarm device whenever the emergency purge mode of operation is activated.

7. Over-Opened Sash

a. The ODP shall also provide an audible sash open alert feature that shall caution users whenever the fume hood sash exceeds a predetermined height.

b. The audible alert shall consist of a series of quick “chirps” that continue until the sash is reduced to an acceptable height.

8. Occupancy and sash closers

a. BMS shall provide monitoring only integration with lighting control for purposes of obtaining occupancy only.

b. When a lab zone is unoccupied for more than 30 min as determined by the occupancy sensors in the lighting system, BMS to roll back the room to the minimum, un-populated cfm values AND command all sash closers to closed.

c. When the building goes into unoccupied schedule, AND if the occupancy status as determined by the lighting control is unpopulated, then command all sash closers to close. ELSE, do nothing until lighting systems shows a change to unoccupied lasting 30 min.

9. Alarms

a. Low Face Velocity
   1) If the calculated face velocity is below its alarm threshold and generating an alarm at the ODP, a Level 2 alarm shall also be generated at the BMS.

b. Low airflow
1) If the measured airflow is less than 70% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 3 alarm.
2) If the measured airflow is less than 50% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 2 alarm.

K. Lab General Exhaust Air Valve

1. General
   a. Lab air valves shall be of the same manufacturer as the building DDC system.
   b. Lab air supply, general exhaust and fume hood exhaust to be controlled from a single controller per the district standard.
   c. Lab exhaust air valves maintain pressurization in the lab via airflow offset control as required for positive, negative, or neutral control relative to adjacent spaces or outside.
   d. This sequence is not to be confused with Fume Hood Lab exhaust air valves which maintain face velocity at all times regardless of zone occupancy status.

2. Zones without fume hoods: Active airflow setpoint at the lab air valve shall vary depending on the setpoint at the local supply air valve as follows:
   a. \[ V_{spt_{labexhaust}} = V_{spt_{labsupply}} + \text{offset} \]
   b. The necessary offset for each room is to be field determined by the air balancer to maintain the room at \( .1'' \) negative (adj).

3. Zones with fume hoods: Active airflow setpoint at the lab air valve shall vary depending on the setpoint at the local supply air valve and the current airflow setpoint of the fume hoods as follows:
   a. \[ V_{spt_{labexhaust}} = V_{spt_{labsupply}} - V_{spt_{labfumehood}} + \text{offset} \]

4. Airflow Control
   a. The Lab Air Valve damper shall be modulated by a PI control loop to maintain the measured airflow at the active setpoint \( V_{spt_{labexhaust}} \).

5. Alarms
   a. Low airflow
   b. If the measured airflow is less than 70% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 3 alarm.
   c. If the measured airflow is less than 50% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 2 alarm.

6. Testing/Commissioning Overrides: Provide software points that interlock to a system level point to
   a. Force zone airflow setpoint \( V_{spt} \) to zero
   b. Force zone airflow setpoint \( V_{spt} \) to \( V_{min} \)
   c. Force damper full closed/open

7. Pressure requests:
   1) If the Damper Loop is less than 85%, send 0 requests
   2) If the Damper Loop is greater than 95%, send 1 request
   3) If the measured airflow is less than 85% of setpoint for 30 seconds, send 3 requests

L. Laboratory Exhaust Fan Stack Control

1. General:
a. At all times the lab fans shall be commanded to run to protect the safety of the public. This need surpasses any occupied or unoccupied mode.

b. Min speed acceptable for any single fan is 12,000 cfm per the wind study. This is a public safety requirement. Use a buffer of 10%.

c. When a single or both fans need to be above 12,000 cfm, and this is above what the building needs, the bypass dampers will modulate to control the negative plenum pressure, so the fans can still provide min speed.

d. Fans are sized at 60% of design need, 3 fans to not need to run simultaneously.

e. Fans will be staged to meet the building demand.

f. Exhaust plenum pressure should initially be set to 2” negative pressure.

g. Once building needs more than 12kcfm from one or both fans, use trim and respond logic to control the fan speed. While described in full elsewhere in this spec, in brief the general exhaust boxes of the labs will be generating requests if they are within 80% of max capacity to satisfy their zone. The exhaust fan setpoint shall receive trim increases to respond to these requests. A PI loop will still control the single or dual fan speed to setpoint which is being reset higher or lower to provide just enough flow until at least one box is at 80% capacity.

2. Exhaust Plenum Pressure Control represented schematically below:

a. First stage of fan supply
   1) Lead fan bypass opens fully while isolation damper is closed
   2) Once both bypass and isolation dampers have reached their commanded state, lead fan ramps up to 12kcfm + 10%.
   3) Simultaneously command:
      a) Isolation damper to be opened
      b) Bypass controls with PI loop to control exhaust plenum pressure setpoint.
      c) Note: some degree of fluctuation is expected until the isolation damper is fully opened. PI loop is expected to achieve setpoint only after isolation damper is shut.
      d) Recommendation: use ramp rate on damper actuators effectively synchronizes their timing of the dampers. (Very negative conditions will slow dampers, but this is not a high precision requirement.)

   4) When the negative plenum pressure requires the bypass to be 90% closed for more than 2 min, switch from bypass control to fan control.

   5) Fan control of the negative plenum to be with trim and respond logic (as described elsewhere in this spec), resetting fan cfm higher to maintain negative plenum pressure. Recommend initial speed increments of 10%, field tuning is still required.

   6) Once the building need for exhaust climbs 10% below max speed of the lead fan for more than 2 minutes, initiate 2nd stage of fan supply.

b. 2nd stage of fan supply
   1) First, the lag fan bypass opens fully.
   2) Once bypass is confirmed full open, lag fan ramps up to 12kcfm + 10%.
   3) Once the fan has reached speed, simultaneously execute the following commands:
      a) Lag fan isolation damper to open
      b) Lead fan and lag fan set to same setpoint of 12kcfm + 10%
      c) Switch from PI plenum control with 1 damper to control with both bypass dampers.
      d) (Note: at this brief transition point, the system has been provided with ample air flow, double what is necessary, fluctuations in the plenum through transition would be normal in this instance. It is not expected
that the plenum would be too positive, but there is a chance it could be too negative. Contractor to use care in selecting ramp rates to Suspend alarms during transition or increase alarm “make” delay time span to prevent nuisance alarms)

4) When the negative plenum pressure requires the bypasses to be 90% closed for more than 2 min, switch from bypass control to fan control.
5) Fan control requires both fans be controlled to the same speed signal with trim and respond logic (as described elsewhere in this spec) by resetting fan cfm higher to control plenum pressure. Recommend initial speed increments of 5% as the fans are now working in tandem, field tuning is still required.

c. Stage down:
1) When both fans are at 24kcfm + 10% for more than 3 min, begin stage down process.
2) Enable both bypasses to control to the same signal as before with stage up.
3) Command the lead fan to ramp up to full speed. (Note: it is expected that the bypasses will be able to modulate and maintain pressure. If instability becomes evident, use more gradual ramp rate on the speed increase.)
4) Once the lead fan has proven full speed simultaneously execute the following commands:
   a) Command lag fan isolation damper closed
   b) Shut down speed of lag fan
   c) Close all bypass dampers
   d) Resume control of plenum pressure with single fan speed complete with trim and respond as before.
   e) Recommendation: use ramp rate on damper actuators effectively synchronizes their timing of the dampers. (Very negative conditions will slow dampers, but this is not a high precision requirement.)

3. In the event of an AHU supply fan failure:
   a. It is expected that all hoods will go into local alarm mode.
   b. All exhaust fans to fall back to the emergency setpoint of -.1” of static so that lab doors are not difficult to open.
   c. All sash closers are commanded to be closed.
   d. Note: such an AHU failure to be detected by a dedicated static pressure sensor on the AHU supply duct back to the EF control panel rather than passed back through the network from the AHU panel.
   e. Fans should obey unique rotation logic as there cannot be a time when there is no service to the building:

1) At the end of 80 hours of run time, enable 3rd fan to run as lag.
2) Fully open 3rd fan bypass damper
3) After bypass damper is proven full open, ramp 3rd fan to present speed of the other 2 fans.
4) When speed of 3rd fan has proven matched, simultaneously perform the following commands:
   a) Open the 3rd fan isolation damper
   b) Open the former lead fan bypass damper
   c) Close the former lead fan isolation damper
   d) The single fan not being pulled out of rotation will still be controlling to plenum pressure.
   e) When the isolation damper of the former lead fan is proven closed, shut off the fan and use the 2 running fans to control to pressure in unison as they normally would.
f) Note: there could be some fluctuation in pressure, however far more air is being supplied than needed. Controls contractor to take care as to not draw plenum too negative.

g) Send the former lead fan which is off to the end of the rotation.

f. Negative plenum pressure to be reset with trim using Trim & Respond logic parameters:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Either EF</td>
</tr>
<tr>
<td>SP0</td>
<td>-1.0 inches</td>
</tr>
<tr>
<td>SPmax</td>
<td>-0.1 inches</td>
</tr>
<tr>
<td>SPmin</td>
<td>-2.0 inches</td>
</tr>
<tr>
<td>Td</td>
<td>10 minutes</td>
</tr>
<tr>
<td>T</td>
<td>2 minutes</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>Zone Exhaust</td>
</tr>
<tr>
<td></td>
<td>Static</td>
</tr>
<tr>
<td></td>
<td>Pressure</td>
</tr>
<tr>
<td></td>
<td>Reset</td>
</tr>
<tr>
<td></td>
<td>Requests</td>
</tr>
<tr>
<td>SPtrim</td>
<td>+0.05 inches</td>
</tr>
<tr>
<td>SPres</td>
<td>-0.06 inches</td>
</tr>
<tr>
<td>SPres-max</td>
<td>-0.13 inches</td>
</tr>
</tbody>
</table>

4. In the event of fire, fire alarm system to provide power kill of the bypass dampers so that plenum pressure is immediately cut.

5. In the event of loss of power,
   a. The BMS will detect loss of power when the duct supply pressure of the supply fan goes to zero. (the supply fan is not on emergency power)
   b. One Exhaust fan is on emergency power, the associated BMS control panel must be as well.
   c. Command the EF with emergency power to run at the minimum safe speed of 12,000 cfm. This will keep the lab plenum negative.
   d. The labs themselves are not on emergency power and all have dampers with spring return actuators. Upon loss of power in those zones the dampers will open to break the potential negative pressure lock on the room. This will prevent these rooms from going too negative to exit.

M. Multiple Zone VAV Air Handlers

1. Air Handling Unit System Modes:
   a. Fully comply with ASHRAE Guideline 36-2018
   b. AHU system Modes are the same as the Mode of the Zone Group served by the system. When Zone Group served by an air handling system are in different modes, the following hierarchy applies (highest one sets AHU mode).

   1) Occupied Mode
   2) Cool-down Mode
   3) Setup Mode
   4) Warm-up Mode
   5) Setback Mode
   6) Freeze Protection Setback Mode
   7) Unoccupied Mode

2. Parameters
   a. Design Information:
1) Temperature Setpoints
   a) Min_ClgSAT, lowest cooling supply air temperature setpoint: 55°F.
   b) Max_ClgSAT, highest cooling supply air temperature setpoint: 65°F.
   c) OAT_Min, the lower value of the OAT reset range: 50°F.
   d) OAT_Max, the higher value of the OAT reset range: 70°F.

2) Ventilation Setpoints
   a) AbsMinOA: the design outdoor airflow rate when all zones with CO2 sensors or occupancy sensors are unpopulated: per AHU schedule
   b) DesMinOA: the design minimum outdoor airflow with areas served by the system are occupied at their design population: per AHU schedule

3) Economizer High Limit: Paragraph 3.1.4.3.2 (California Title 24 economizer high limit requirements)
   a) California Climate Zone: 3

b. TAB Information
   1) Duct design maximum static pressure, Max_DSP to be determined by Section 230593 Testing, Adjusting and Balancing.
   2) Minimum Fan Speed: Per Paragraph 3.15E.7

3. Supply Fan Control
   1) Staged supply fan controls
      a) VFD Fan groups shall be lead/lag controlled per Paragraph 3.13B.5.
      b) When fans are enabled, start the lead supply fan. When %-supply airflow (totalized enabled VAV box readings divided by design AHU airflow) exceeds stage-up setpoint (below) for 15 minutes (adjustable) then the next lag supply fan shall run. All VFDs receive the same speed signal. When %-airflow falls below the stage-up setpoint for 15 (adjustable) minutes then last lag fan shall be staged off.

<table>
<thead>
<tr>
<th>VFD Stage</th>
<th>Stage up Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>15%</td>
</tr>
<tr>
<td>3</td>
<td>20%</td>
</tr>
<tr>
<td>4</td>
<td>25%</td>
</tr>
<tr>
<td>5</td>
<td>30%</td>
</tr>
<tr>
<td>6</td>
<td>45%</td>
</tr>
</tbody>
</table>

4. Supply Fan Start/Stop
   a. Supply fan shall run when system is in the Cool-down Mode, Setup Mode, or Occupied Mode.
      1) If there are any VAV-reheat boxes on perimeter zones, supply fan shall also run when system is in Setback Mode or Warm-up Mode (i.e., all Modes except Unoccupied).
      2) Totalize current airflow rate from VAV boxes to a software point, Vps.
   b. Static Pressure Control
      1) Supply fan speed is controlled with PI loop to to maintain duct static pressure at setpoint when the fan is proven on.
      2) Use initial pressure setpoint of .5” w.c. and apply trim and respond logic (described below) to adjust setpoint to satisfy zones.
High pressure trips may occur if all VAV boxes are closed (as in Unoccupied Mode) or if fire/smoke dampers are closed (in some FSD designs, the dampers are interlocked to the fan status rather than being controlled by smoke detectors). Multiple sets of gains are used to provide control loop stability as system characteristics change.

c. Static Pressure Setpoint Reset

1) Static pressure setpoint: Setpoint shall be reset using Trim & Respond using the following parameters:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Supply Fan</td>
</tr>
<tr>
<td>SP0</td>
<td>120 Pa. (0.5 inches)</td>
</tr>
<tr>
<td>SPmin</td>
<td>25 Pa. (0.1 inches)</td>
</tr>
<tr>
<td>SPmax</td>
<td>Max_DSP</td>
</tr>
<tr>
<td>Td</td>
<td>10 minutes</td>
</tr>
<tr>
<td>T</td>
<td>2 minutes</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>Zone Static Pressure Reset Requests</td>
</tr>
<tr>
<td>SPtrim</td>
<td>-12 Pa (-0.05 inches)</td>
</tr>
<tr>
<td>SPres</td>
<td>15 Pa (+0.06 inches)</td>
</tr>
<tr>
<td>SPres-max</td>
<td>32 Pa (+0.13 inches)</td>
</tr>
</tbody>
</table>

The trim & respond reset parameters above are suggested as a starting place; they will most likely require adjustment during the commissioning/tuning phase.

5. Return Fan Control

a. Return fan shall be controlled to track the supply fan setpoint with an offset.
b. This offset should initially be set to 1200 cfm.
c. The exhaust fans for restrooms are pulling approx. 3000 cfm and the labs will exhaust an additional 1200 cfm from the common areas.
d. To achieve the 1200 cfm offset the return fan should maintain an offset of 4000 cfm from the AHU supply fan.

6. Supply Air Temperature Control (return fan with airflow tracking)
a. Supply air temperature shall be controlled to setpoint using a control loop whose output is mapped to sequence the heat recovery coil with heat recovered water, HHW from the ASHP, and economizer as shown in the diagram below.
b. The points of transition along the x-axis shown and described above are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, heat recovery wheel), that are determined by DDC Contractor to provide stable control. DDC Contractor shall also adjust the precise value of the x-axis thresholds shown in the figure to provide stable control.

c. Economizer damper maximum (MaxOA-P) position is limited for economizer high limit lockout.

d. For units with a separate minimum outdoor air damper: MinOA-P is 0% and MaxRA-P is modulated to maintain minimum outdoor airflow.

1) For units with a separate minimum outdoor air damper: Economizer damper minimum position (MinOA-P) is 0% and return air damper maximum position (MaxRA-P) is modulated to control minimum outdoor air

2) For units with a single common minimum outdoor air and economizer damper: Return air damper maximum position (MaxRA-P) and economizer damper minimum position (MinOA-P) are modulated to control minimum outdoor air volume [see 3.13M.9].

3) To stage up from heat recovery water to ASHP HHW:

a) Heat recovery pump is throttled with PI loop to provide additional heat according to discharge air temp.

b) If the HHW valve is 100% open AND the Heat recovery pump is full speed to provide max heating available, but the discharge air temp is not able to maintain setpoint for 5 minutes, the coil will need to receive
hotter water from the ASHP. Accomplish this sequence in the following way:
c) IF AHSP is currently producing HHW, initiate change over from heat recovery water to ASHP HHW.
d) ELSE, send signal to ASHP equipment to start producing HHW at setpoint on the mechanical schedule. When ASHP HHW is available, through BACnet signal or supply water temp sensor, initiate heat recovery coil valve change over sequence.
e) HHW valve change over sequence:
   (1) From heat recovery water to ASHP water:
      (a) First shut down the heat recovery pump,
      (b) Once proven off, begin opening ASHP HHW valves,
      (c) Once proven open, close heat recovery valves.
      (d) In that order, this prevents deadheading the pump.
   (2) From ASHP to heat recovery water:
      (a) Open heat recovery valves,
      (b) Once proven open, lose the ASHP HHW valves,
      (c) Once proven closed, start the PI loop to control the heat recovery pump to control heating.

7. Plant Requests
   a. ASHP Plant Requests. Send the ASHP plant that serves the zone a ASHP Plant Request as follows:
      1) If the HHW valve position is greater than 95%, send 1 Request

8. Minimum Outdoor Airflow Setpoints
   a. DP setpoint, for California Title 24 ventilation:
      1) See Error! Reference source not found. for design OA DP setpoints.
      2) See Error! Reference source not found. for calculation of current setpoints, AbsMinOA* and DesMinOA*.
      3) See zone CO₂ control logic under terminal unit sequences.
      a) The active minimum differential pressure setpoints, AbsDPsp* and DesDPsp*, shall be determined by the equations below:
      \[
      \text{AbsDPsp}^* = \text{AbsMinDP} \left[ \frac{\text{AbsMinOA}^*}{\text{AbsMinOA}} \right]^2 \\
      \text{DesDPsp}^* = \text{DesMinDP} \left[ \frac{\text{DesMinOA}^*}{\text{DesMinOA}} \right]^2
      \]
      4) The minimum outdoor air DP setpoint (MinDPsp) shall be reset based on the highest zone CO₂ control loop signal from AbsDPsp* at 50% signal to DesDPsp* at 100% signal.
      5) The minimum outdoor air setpoint (MinOAsp) shall be reset based on the highest zone CO₂ control loop signal from AbsMinOA* at 50% signal to DesMinOA* at 100% signal.

9. Minimum Outdoor Air Control with a single common damper for minimum outdoor air and economizer functions, and airflow measurement
   a. Outdoor airflow setpoint, for California Title 24 ventilation:
      1) See Error! Reference source not found. for calculation of current setpoints, AbsMinOA* and DesMinOA*. 
2) See zone CO₂ control logic under terminal unit sequences.
3) The minimum outdoor air setpoint MinOAsp shall be reset based on the highest zone CO₂ control loop signal from AbsMinOA* at 50% signal to DesMinOA* at 100% signal.

Figure 5.16.6.3. Minimum Outdoor Airflow Control Mapping with Single Damper

10. Economizer High Limit Lockout
   a. When economizer is enabled, MaxOA-P = 100%.
   b. Once the economizer is disabled, it shall not be re-enabled within 10 minutes, and vice versa.
   c. When the economizer is disabled:
      1) Return air damper shall be fully opened
      2) Wait 15 seconds, then set MaxOA-P equal to MinOA-P.
      3) Wait 3 minutes, then release return air damper for minimum outdoor air control.

The return air damper is at first opened to avoid drawing the mixing plenum too negative. The three-minute delay is because the minimum OA damper may be pressure controlled. In that case, delay allows time for the plenum pressure to stabilize so that the return damper loop does not become unstable chasing a fluctuating pressure reading.

11. Freeze Protection

   a. If the supply air temperature drops below 4.4°C (40°F) for 5 minutes, send two (or more, as required to ensure that heating plant is active) Heating Hot Water Plant Requests, override the outdoor air damper to the minimum position, and modulate the heating coil to maintain a supply air temperature of at least 6°C (42°F). Disable this function when supply air temperature rises above 7°C (45°F) for 5 minutes.

   There are three stages of freeze protection. The first stage modulates the heating valve to maintain a safe SAT. The second stage eliminates outdoor air ventilation, in case heating is not available for whatever reason. The third stage shuts down the unit and activates coil valves and pumps to circulate water, in case the second stage does not work (e.g., stuck economizer damper).
The first stage of freeze protection locks out the economizer. Most likely this has already occurred by this time, but this logic provides insurance.

b. If the supply air temperature drops below 3.3°C (38°F) for 5 minutes, fully close both the economizer damper and the minimum outdoor air damper for one hour, and set a Level 3 alarm noting that minimum ventilation was interrupted. After one hour, the unit shall resume minimum outdoor air ventilation and enter the previous stage of freeze protection (see 3.13M.11.a).

A timer is used (rather than an OAT threshold) to exit the second stage of freeze protection because a bad OAT sensor could lock out ventilation indefinitely, while a timer should just work and thus avoid problems with the unit getting “stuck” in this mode with no ventilation.

Upon timer expiration, the unit will re-enter the previous stage of freeze protection (minOA ventilation, with heating to maintain SAT of 6°C (42°F)), after which one of three possibilities will occur:

1) If it is warm enough that the SAT rises above 7°C (45°F) with minimum ventilation, the unit will remain in Stage “1” freeze protection for five minutes, then resume normal operation.

2) If it is cold enough that SAT remains between 3.3°C (38°F) and 7°C (45°F) with heating and minimum ventilation, the unit will remain in Stage “1” freeze protection indefinitely, until outdoor conditions warm up.

3) If it is so cold that SAT is less than 3.3°F (38°F) with minimum ventilation, despite heating, then the unit will revert to Stage “2” freeze protection, where it will remain for one hour. This process will then repeat.

c. Upon signal from the freeze-stat (if installed) or if supply air temperature drops below 3.3°C (38°F) for 15 minutes or below 1°C (34°F) for 5 minutes, shut down supply and return/relief fan(s), close outdoor air damper, open the cooling coil valve to 100%, and energize the chilled water pump system. Also send two (or more, as required to ensure that heating plant is active) Heating Hot Water Plant Requests, modulate the heating coil to maintain the higher of the supply air temperature or the mixed air temperature at 27°C (80°F), and set a Level 2 alarm indicating the unit is shut down by freeze protection.

1) If a freeze protection shutdown is triggered by a low air temperature sensor reading, it shall remain in effect until it is reset by a software switch from the operator’s workstation. (If a freeze stat with a physical reset switch is used instead, there shall be no software reset switch.)

Stage three can be triggered by either of two conditions. The second condition is meant to respond to an extreme and sudden cold snap.

Protecting the cooling coil in this situation will require water movement through the coil, which means that the CHW pumps need to be energized.

Heating coil is controlled to an air temperature setpoint. The sensors will not read accurately with the fan off, but they will be influenced by proximity to the heating coil. A temperature of 27°C (80°F) at either of these sensors indicates that the interior of the unit is sufficiently warm. This avoids the situation where a fixed valve position leads to very high (and potentially damaging) temperatures inside the unit.

12. Alarms

a. Maintenance interval alarm when fan has operated for more than 1,500 hours: Level 4. Reset interval count when alarm is acknowledged.
b. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.
   1) Commanded on, status off: Level 2
   2) Commanded off, status on: Level 4

c. Filter pressure drop exceeds alarm limit: Level 4. The alarm limit shall vary with total airflow (if available; use fan speed if total airflow is not known) as follows:

\[ DP_x = DP_{100} (x)^{1.4} \]

where \( DP_{100} \) is the high limit pressure drop at design airflow (determine limit from filter manufacturer) and \( DP_x \) is the high limit at the current airflow rate \( x \) (expressed as a fraction). For instance, the setpoint at 50% of design airflow would be \((.5)^{1.4}\) or 38% of the design high limit pressure drop.

d. High building pressure [more than 25 Pa (0.10")]: Level 3

e. Low building pressure (less than 0 Pa (0.0"), i.e., negative): Level 4

f. Automatic Fault Detection and Diagnostics

The Automatic Fault Detection and Diagnostics (AFDD) routines for AHUs continually assess AHU performance by comparing the values of BAS inputs and outputs to a subset of potential fault conditions. The subset of potential fault conditions that is assessed at any point depends on the Operating State of the AHU, as determined by the position of the cooling and heating valves and the economizer damper. Time delays are applied to the evaluation and reporting of fault conditions, to suppress false alarms. Fault conditions that pass these filters are reported to the building operator along with a series of possible causes.

These equations assume that the air handler is equipped with hydronic heating and cooling coils, as well as a fully integrated economizer. If any of these components are not present, the associated tests, and variables should be omitted from the programming.

Note that these alarms rely on reasonably accurate measurement of mixed air temperature. An MAT sensor is required for many of these alarms to work, and an averaging sensor is strongly recommended for best accuracy.

1) AFDD conditions are evaluated continuously and separately for each operating air handling unit.
2) The Operating State (OS) of each AHU shall be defined by the commanded positions of the heating coil control valve, cooling coil control valve, and economizer damper in accordance with the following table and corresponding graphic.

The Operating State is distinct from and should not be confused with the Zone Status (Cooling, Heating, Deadband) or Zone Group Mode (Occupied, Warm-up, etc.).

OS#1 – OS#4 represent normal operation during which a fault may nevertheless occur, if so determined by the fault condition tests in section e below. By contrast, OS#5 may represent an abnormal or incorrect condition (such as simultaneous heating and cooling) arising from a controller failure or programming error, but it may also occur normally, e.g., when dehumidification is active or during warm-up.
Operating State | Heating Valve Position | Cooling Valve Position | Outdoor Air Damper Position
---|---|---|---
#1: Heating | > 0 | = 0 | = MIN
#2: Free Cooling, Modulating OA | = 0 | = 0 | MIN < X < 100%
#3: Mechanical + Economizer Cooling | = 0 | > 0 | = 100%
#4: Mechanical Cooling, Minimum OA | = 0 | > 0 | = MIN
#5: Unknown or Dehumidification | | | No other OS applies

Figure 5.16.14.2. VAV AHU Operating States

3) The following points must be available to the AFDD routines for each AHU:

- SAT = Supply air temperature
- MAT = Mixed air temperature
- RAT = Return air temperature
- OAT = Outdoor air temperature
- DSP = Duct static pressure
- SATSP = supply air temperature setpoint
- DSPSP = duct static pressure setpoint
- HC = heating coil valve position command; 0% ≤ HC ≤ 100%
- FS = fan speed command; 0% ≤ FS ≤ 100%

For the AFDD routines to be effective, an averaging sensor is recommended for supply air temperature. An averaging sensor is essential for mixed air temperature, as the environment of the mixing box will be subject to non-uniform and fluctuating air temperatures. It is recommended that the OAT sensor be located at the AHU, so that it accurately represents the temperature of the incoming air.
j) HCET = heating coil entering temperature; depending on the AHU configuration, this could be the MAT or a separate sensor for this specific purpose.

k) HCLT = heating coil leaving temperature; depending on the AHU configuration, this could be the SAT or a separate sensor for this specific purpose.

4) The following values must be continuously calculated by the AFDD routines for each AHU:

a) 5-minute rolling averages with 1-minute sampling time of the following point values; operator shall have the ability to adjust the averaging window and sampling period for each point independently

   (1) SAT<sub>AVG</sub> = rolling average of supply air temperature
   (2) MAT<sub>AVG</sub> = rolling average of mixed air temperature
   (3) RAT<sub>AVG</sub> = rolling average of return air temperature
   (4) OAT<sub>AVG</sub> = rolling average of outdoor air temperature
   (5) DSP<sub>AVG</sub> = rolling average of duct static pressure
   (6) HCET<sub>AVG</sub> = rolling average of heating coil entering temperature
   (7) HCLT<sub>AVG</sub> = rolling average of heating coil leaving temperature

b) %OA = actual outdoor air fraction as a percentage = \( \frac{\text{MAT} - \text{RAT}}{\text{OAT} - \text{RAT}} \) or per airflow measurement station if available.

c) %OA<sub>MIN</sub> = Active minimum OA setpoint (MinOAsp) divided by actual total airflow (from sum of VAV box flows, or by airflow measurement station) as a percentage.

d) ΔOS = number of changes in Operating State during the previous 60 minutes (moving window)

5) The following internal variables shall be defined for each AHU. All parameters are adjustable by the operator, with initial values as given below:

```
<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔT&lt;sub&gt;SF&lt;/sub&gt;</td>
<td>Temperature rise across supply fan</td>
<td>1°C (2°F)</td>
</tr>
<tr>
<td>ΔT&lt;sub&gt;MIN&lt;/sub&gt;</td>
<td>Minimum difference between OAT and RAT to evaluate economizer error conditions (FC#6)</td>
<td>6°C (10°F)</td>
</tr>
<tr>
<td>Ɛ&lt;sub&gt;SAT&lt;/sub&gt;</td>
<td>Temperature error threshold for SAT sensor</td>
<td>1°C (2°F)</td>
</tr>
</tbody>
</table>
```

*Default values are derived from NISTIR 7365 (Jeffrey Schein, October 2006) and have been validated in field trials. They are expected to be appropriate for most circumstances, but individual installations may benefit from tuning to improve sensitivity and reduce false alarms.

The default values have been intentionally biased towards minimizing false alarms, if necessary at the expense of missing real alarms. This avoids excessive false alarms that will erode user confidence and responsiveness. However, if the goal is to achieve the best possible energy performance and system operation, these values should be adjusted based on field measurement and operational experience.

Values for physical factors such as fan heat, duct heat gain, and sensor error can be measured in the field or derived from trend logs. Likewise, the occupancy delay and switch delays can be refined by observing in trend data the time required to achieve quasi steady state operation.

Other factors can be tuned by observing false positives and false negatives (i.e., unreported faults). If transient conditions or noise cause false errors, increase the alarm delay. Likewise, failure to report real faults can be addressed by adjusting the heating coil, cooling coil, temperature, or flow thresholds.*
<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varepsilon_{\text{RAT}}$</td>
<td>Temperature error threshold for RAT sensor</td>
<td>$1^\circ\text{C (2}^\circ\text{F)}$</td>
</tr>
<tr>
<td>$\varepsilon_{\text{MAT}}$</td>
<td>Temperature error threshold for MAT sensor</td>
<td>$3^\circ\text{C (5}^\circ\text{F)}$</td>
</tr>
<tr>
<td>$\varepsilon_{\text{OAT}}$</td>
<td>Temperature error threshold for OAT sensor</td>
<td>$1^\circ\text{C (2}^\circ\text{F)}$ if local sensor @ unit. $3^\circ\text{C (5}^\circ\text{F)}$ if global sensor.</td>
</tr>
<tr>
<td>$\varepsilon_{\text{F}}$</td>
<td>Airflow error threshold</td>
<td>$30%$</td>
</tr>
<tr>
<td>$\varepsilon_{\text{VFDSPD}}$</td>
<td>VFD speed error threshold</td>
<td>$5%$</td>
</tr>
<tr>
<td>$\varepsilon_{\text{DSP}}$</td>
<td>Duct static pressure error threshold</td>
<td>$25\text{ Pa (0.1}^\prime\text{)}$</td>
</tr>
<tr>
<td>$\varepsilon_{\text{CCET}}$</td>
<td>Cooling coil entering temperature sensor error. Equal to $\varepsilon_{\text{MAT}}$ or dedicated sensor error</td>
<td></td>
</tr>
<tr>
<td>$\varepsilon_{\text{CCLT}}$</td>
<td>Cooling coil leaving temperature sensor error. Equal to $\varepsilon_{\text{SAT}}$ or dedicated sensor error</td>
<td>Varies, see Description</td>
</tr>
<tr>
<td>$\varepsilon_{\text{HCET}}$</td>
<td>Heating coil entering temperature sensor error; equal to $\varepsilon_{\text{MAT}}$ or dedicated sensor error</td>
<td></td>
</tr>
<tr>
<td>$\varepsilon_{\text{HCLT}}$</td>
<td>Heating coil leaving temperature sensor error. Equal to $\varepsilon_{\text{SAT}}$ or dedicated sensor error</td>
<td></td>
</tr>
<tr>
<td>$\Delta OS_{\text{MAX}}$</td>
<td>Maximum number of changes in Operating State during the previous 60 minutes (moving window)</td>
<td>$7$</td>
</tr>
<tr>
<td>ModeDelay</td>
<td>Time in minutes to suspend Fault Condition evaluation after a change in Mode</td>
<td>$30$</td>
</tr>
<tr>
<td>AlarmDelay</td>
<td>Time in minutes to that a Fault Condition must persist before triggering an alarm</td>
<td>$30$</td>
</tr>
<tr>
<td>TestModeDelay</td>
<td>Time in minutes that Test Mode is enabled</td>
<td>$120$</td>
</tr>
</tbody>
</table>

The purpose of $\Delta T_{\text{MIN}}$ is to ensure that the mixing box/economizer damper tests are meaningful. These tests are based on the relationship between supply, return, and outdoor air. If $\text{RAT} \approx \text{MAT}$, these tests will not be accurate and will produce false alarms.

The purpose of TestModeDelay is to ensure that normal fault reporting occurs after the testing and commissioning process is completed as prescribed in 3.13M.12.q.

6) The following are potential Fault Conditions that can be evaluated by the AFDD routines. If the equation statement is true, then the specified fault condition exists. The Fault Conditions to be evaluated at any given time will depend on the Operating State of the AHU.

These equations assume that the SAT sensor is located downstream of the supply fan, and the RAT sensor is located downstream of the return fan. If actual sensor locations differ from these assumptions, it may be necessary to add or delete fan heat correction factors.

To detect the required economizer faults in Title 24 section 120.2(i)(7), use Fault Conditions #2, 3, and 5-13 at a minimum. Other Title 24 AFDD requirements, including acceptance tests, are not met through these fault conditions.
<table>
<thead>
<tr>
<th>FC#</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
<th>Applies to OS</th>
</tr>
</thead>
</table>
| #1  | \( DSP < DSPSP - \varepsilon_{DSP} \) and \( VFDS\) \( \geq 99\% - \varepsilon_{VFDS} \) | Duct static pressure is too low with fan at full speed | Problem with VFD  
Mechanical problem with fan  
Fan undersized  
SAT Setpoint too high (too much zone demand) | #1 – #5       |
| #2  | \( \text{MAT}_{\text{AVG}} + \varepsilon_{\text{MAT}} < \min[(\text{RAT}_{\text{AVG}} - \varepsilon_{\text{RAT}}), (\text{OAT}_{\text{AVG}} - \varepsilon_{\text{OAT}})] \) | MAT too low; should be between OAT and RAT | RAT sensor error  
MAT sensor error  
OAT sensor error | #1 – #5       |
| #3  | \( \text{MAT}_{\text{AVG}} - \varepsilon_{\text{MAT}} > \max[(\text{RAT}_{\text{AVG}} + \varepsilon_{\text{RAT}}), (\text{OAT}_{\text{AVG}} + \varepsilon_{\text{OAT}})] \) | MAT too high; should be between OAT and RAT | RAT sensor error  
MAT sensor error  
OAT sensor error | #1 – #5       |
| #4  | \( \Delta OS > \Delta OS_{\text{MAX}} \) | Too many changes in Operating State | Unstable control due to poorly tuned loop or mechanical problem | #1 – #5       |
| #5  | \( \text{SAT}_{\text{AVG}} + \varepsilon_{\text{SAT}} \leq \text{MAT}_{\text{AVG}} - \varepsilon_{\text{MAT}} + \Delta T_{\text{SF}} \) | SAT too low; should be higher than MAT | SAT sensor error  
MAT sensor error  
Heating coil valve stuck closed or actuator failure  
Fouled or undersized heating coil  
HW temperature too low or HW unavailable  
Gas or electric heat unavailable  
DX cooling stuck on | #1       |
| #6  | \( |\text{RAT}_{\text{AVG}} - \text{OAT}_{\text{AVG}}| \geq \Delta T_{\text{MIN}} \) and \( |\%OA - \%OA_{\text{MIN}}| > \varepsilon_{F} \) | OA fraction is too low or too high; should equal \( \%OA_{\text{MIN}} \) | RAT sensor error  
MAT sensor error  
OAT sensor error  
Leaking or stuck economizer damper or actuator | #1, #4     |
<table>
<thead>
<tr>
<th>Equation</th>
<th>SAT&lt;sub&gt;Avg&lt;/sub&gt; &lt; SAT&lt;sub&gt;SATSP&lt;/sub&gt; - Ɛ&lt;sub&gt;SAT&lt;/sub&gt; and HC ≥ 99%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>SAT too low in full heating</td>
</tr>
<tr>
<td>Possible Diagnosis</td>
<td>SAT sensor error, Heating coil valve stuck closed or actuator failure, Fouled or undersized heating coil, HW temperature too low or HW unavailable, Gas or electric heat unavailable, DX cooling stuck on, Leaking or stuck economizer damper or actuator</td>
</tr>
<tr>
<td>Applies to OS #1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equation</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applies to OS #1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FC#8 (omit if no MAT sensor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Possible Diagnosis</td>
</tr>
<tr>
<td>Applies to OS #2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FC#10 (omit if no MAT sensor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Equation</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
2) FC#2: MAT too low; should be between RAT and OAT
3) FC#3: MAT too high; should be between RAT and OAT
4) FC#4: Too many changes in Operating State
5) FC#8: SAT and MAT should be approximately equal
6) FC#9: OAT is too high for free cooling without mechanical cooling
7) FC#14: Temperature drop across inactive cooling coil
8) FC#15: Temperature rise across inactive heating coil

j. In OS#3 (Mechanical + 100% Economizer Cooling), the following Fault Conditions shall be evaluated:
   1) FC#1: Duct static pressure is too low with fan at full speed
   2) FC#2: MAT too low; should be between RAT and OAT
   3) FC#3: MAT too high; should be between RAT and OAT
   4) FC#4: Too many changes in Operating State
   5) FC#10: OAT and MAT should be approximately equal
   6) FC#11: OAT too low for 100% OA
   7) FC#12: SAT too high; should be less than MAT
   8) FC#13: SAT too high in full cooling
   9) FC#15: Temperature rise across inactive heating coil

k. In OS#4 (Mechanical Cooling, Min OA), the following Fault Conditions shall be evaluated:
   1) FC#1: Duct static pressure is too low with fan at full speed
   2) FC#2: MAT too low; should be between RAT and OAT
   3) FC#3: MAT too high; should be between RAT and OAT
   4) FC#4: Too many changes in Operating State
   5) FC#6: OA fraction is too low or too high; should equal %OAMIN
   6) FC#12: SAT too high; should be less than MAT
   7) FC#13: SAT too high in full cooling
   8) FC#15: Temperature rise across inactive heating coil

l. In OS#5 (Other), the following Fault Conditions shall be evaluated:
   1) FC#1: Duct static pressure is too low with fan at full speed
   2) FC#2: MAT too low; should be between RAT and OAT
   3) FC#3: MAT too high; should be between RAT and OAT
   4) FC#4: Too many changes in Operating State

m. For each air handler, the operator shall be able to suppress the alarm for any Fault Condition.

n. Evaluation of Fault Conditions shall be suspended under the following conditions:
   1) When AHU is not operating.
   2) For a period of ModeDelay minutes following a change in Mode (e.g., from Warm up to Occupied) of any Zone Group served by the AHU.

o. Fault Conditions that are not applicable to the current Operating State shall not be evaluated.

p. A Fault Condition that evaluates as true must do so continuously for AlarmDelay minutes before it is reported to the operator.

q. Test Mode shall temporarily set ModeDelay and AlarmDelay to 0 minutes for a period of TestModeDelay minutes to allow instant testing of the AFDD system, and ensure normal fault detection occurs after testing is complete.

r. When a Fault Condition is reported to the operator, it shall be a Level 3 alarm and shall include the description of the fault and the list of possible diagnoses from the table in 3.13M.12.f.6).

13. Testing/Commissioning Overrides: Provide software switches that interlock to a chilled water and hot water plant level to
a. If there is a hot water coil, force hot water valve full open
b. If there is a hot water coil, force hot water valve full closed

, all hardware points can be overridden through the BAS. Each of the following points is interlocked so that they can be overridden together at a Zone Group level

E.g., The CxA can check for leaking dampers by forcing all VAV boxes in a Zone Group closed and then recording airflow at the AHU.

Central plant sequences are not part of the initial scope of Guideline 36, but control logic for Plant Requests are being included for future use, when central plant sequences are added.

Typically, the chiller or heating hot water plant will start when there is at least one request for 5 minutes and stop when there are no requests for 5 minutes, after a minimum run-time has elapsed.

Chilled Water and Hot Water reset requests are used in Trim & Respond loops to control supply water temperature and/or pump DP setpoints based on zone and AHU demands.

14. Plant Requests

a. HHW Reset Requests
   1) If the supply air temperature is 17°C (30°F) less than setpoint for 5 minutes, send 3 Requests,
   2) Else if the supply air temperature is 8°C (15°F) less than setpoint for 5 minutes, send 2 Requests,
   3) Else if HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 85%,
   4) Else if the HW valve position is less than 95%, send 0 Requests

b. If there is a hot water coil, Heating Hot Water Plant Requests. Send the heating hot water plant that serves the AHU a Heating Hot Water Plant Request as follows:
   1) If the HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 10%
   2) Else if the HW valve position is less than 95%, send 0 Requests.

N. Variable Speed 2-pipe Fan-Coils

1. See Paragraph 3.13D for setpoints, loops, control modes, alarms, etc.
2. Fan control
   a. During the Cooling mode
      1) FCU serving electrical rooms: the fan shall run when zone is in Cooling Mode. It shall be off otherwise.
      2) FCU serving IDF or server room rooms: the fan shall be enabled to run 24/7
   3. Supply Fan Speed and Supply Air Temperature Setpoint Control
      a. When supply fan is proven on, supply air temperature setpoint and fan speed setpoints shall be as follows:
1) Setpoints (individually adjustable by unit from graphic):
   a) Maximum SAT Setpoint: Current cooling space temperature setpoint
   b) Minimum SAT Setpoint: Design cooling coil leaving air temperature per coil schedule
   c) Maximum Cooling Speed: that required to deliver design airflow to the zone; coordinate with air balancer.
   d) Minimum Speed: 30% of maximum cooling speed

2) When the zone served by the system is in the Cooling Mode, supply air temperature shall be reset from Deadband SAT Setpoint at 0% Cooling Loop output signal down to Minimum SAT Setpoint at 50% PID signal. Fan speed shall be reset from Minimum Speed at 50% cooling PID signal and below, proportionally up to Maximum Cooling Speed at 100% cooling PID signal.

4. Supply Air Temperature Control
   a. Control loop is enabled when the supply air fan is proven on, and disabled and output set to zero otherwise. When loop is disabled, slowly reduce loop output to zero to prevent sudden pressure changes in the CHW flow distribution system.
   b. Supply air temperature shall be controlled to setpoint using a PID loop whose output is mapped to the chilled water valve.

5. Alarms
   a. Maintenance interval alarm when fan has operated for more than 1500 hours: Level 4. Reset interval counter when alarm is acknowledged.
   b. Fan alarm is indicated by the status input being different from the output command after a period of 15 seconds after a change in output status.
      1) Commanded on, status off: Level 2
      2) Commanded off, status on: Level 4
   c. High supply air temperature (more than 5°F above setpoint) off cooling coils when coil control loop is active for longer than 5 minutes: Level 3.

6. Testing/Commissioning Overrides: Provide software points that interlock to a chilled water plant level point to
   a. Force chilled water valve full open
b. Force chilled water valve full closed

7. Plant Requests
a. ASHP Plant Requests. Send the ASHP plant that serves the zone a ASHP Plant Request as follows:
   1) If the CHW valve position is greater than 95%, send 1 Request
   2) Else if the CHW valve position is less than 90%, send 0 Requests.

O. Air-Cooled Chilled Water Plant
1. Parameters:
   a. Temperature Setpoints
      1) CHWSTmin, the lowest chilled water supply temperature setpoint
      2) CH-LOT, the outdoor air lockout temperature below which the ASHP plant is prevented from operating
   b. Minimum Flow Setpoint
      1) CHW-MinFlowSP, the minimum ASHP chilled water flowrate per manufacturer’s recommendations
   c. Capacity
      1) Qdesign, design plant capacity in tons
      2) Qstage, design capacity in tons for each stage
      3) CHWFdesign, design primary loop flow in gpm
   d. Minimum Cycling Load
      1) MinUnloadTons, see manufacturer submittal data
   e. CHW Pump DP setpoint
      1) CHW-DPmax = as determine under 230593 Testing, Adjusting and Balancing.

2. Plant Enable/Disable
   a. The ASHP plant shall include an enabling schedule that allows operators to lock out the plant during off-hours, e.g. to allow off-hour operation of HVAC systems except the ASHP plant. The default schedule shall be 24/7 (adjustable).

3. ASHP CHW Staging
   a. ASHPs shall obey lead/lag control guidelines outlined in Paragraph 3.13B.5.
   b. If an ASHP is in alarm, pull that unit out of rotation and annunciate at the front end.
   c. The ASHP factory controls will manage any internal compressor stages that are internal to that unit. BMS to send enable command to the factory controls with hardware connection when the load in the secondary loop exceeds the capacity of a given unit.
   d. \( Q_{\text{required}} \) is calculated based on secondary flow btu meter. \( Q_{\text{required}} \) used in logic shall be a 5-minute rolling average of instantaneous values sampled at a minimum of every 30 seconds to prevent short cycling of ASHP.
   e. When a stage up or stage down transition is initiated, hold \( Q_{\text{required}} \) fixed at its last value until the longer of the successful completion of the stage change (e.g. lag ASHP proven on) and 15 minutes.
   f. Stage up to a 2nd or 3rd ASHP when the current secondary load is 80% of the tons available.
   g. Stage down to fewer ASHP when current load is at 40% of available capacity.

4. Chilled Water Plant Reset
a. Differential Pressure Controlled Loops: Chilled water supply temperature setpoint CHWSTsp and pump differential pressure setpoint CHW-DPsp shall be reset based on the current value of the logic variable called “CHW Plant Reset” as shown below and described subsequently.

![Diagram of Differential Pressure Controlled Loops]

**1st stage CHW plant reset**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Any CHW Pump</td>
</tr>
<tr>
<td>SP₀</td>
<td>100%</td>
</tr>
<tr>
<td>SPᵦᵣₘᵦ</td>
<td>0%</td>
</tr>
<tr>
<td>SPₘᵦᵣₓ</td>
<td>100%</td>
</tr>
<tr>
<td>Tᵣₑ</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Tₑ</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Iᵣₑ</td>
<td>2</td>
</tr>
<tr>
<td>Rᵣₑ</td>
<td>Cooling</td>
</tr>
<tr>
<td>CHWST Reset Requests</td>
<td></td>
</tr>
<tr>
<td>SPᵦᵣₘᵦ</td>
<td>-2%</td>
</tr>
<tr>
<td>SPᵦᵣₘᵦ</td>
<td>+3%</td>
</tr>
<tr>
<td>SPᵦᵣₘᵦ</td>
<td>+7%</td>
</tr>
</tbody>
</table>

**2nd stage CHW plant reset**

1) CHW Plant Reset shall be reset using Trim & Respond logic (see Guideline 36) with the following parameters as initial setpoints:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Any CHW Pump</td>
</tr>
<tr>
<td>SP₀</td>
<td>100%</td>
</tr>
<tr>
<td>SPᵦᵣₘᵦ</td>
<td>0%</td>
</tr>
<tr>
<td>SPₘᵦᵣₓ</td>
<td>100%</td>
</tr>
<tr>
<td>Tᵣₑ</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Tₑ</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Iᵣₑ</td>
<td>2</td>
</tr>
<tr>
<td>Rᵣₑ</td>
<td>Cooling</td>
</tr>
<tr>
<td>CHWST Reset Requests</td>
<td></td>
</tr>
<tr>
<td>SPᵦᵣₘᵦ</td>
<td>-2%</td>
</tr>
<tr>
<td>SPᵦᵣₘᵦ</td>
<td>+3%</td>
</tr>
<tr>
<td>SPᵦᵣₘᵦ</td>
<td>+7%</td>
</tr>
</tbody>
</table>

2) Note: the initial setpoint is for CHW to be at max with max pumping.
3) Initially CHWST-min = as scheduled
4) CHWST-max = 5 degrees higher. Note: the control valves at the VAV boxes are all based on having constant temperature. If the CHW reset is too aggressive the zone valves will “hunt” or struggle to maintain setpoint.
5) CHW
6) CHWST Plant Reset loop shall be enabled when the plant is enabled and
disabled when the plant is disabled.
7) When a plant stage change is initiated, CHW Plant Reset logic shall be
disabled and value fixed at its last value for the longer of 15 minutes and the
time it takes for the plant to successfully stage.

5. Primary Hot Water Pumps
   a. These are controlled in fully the OEM controller on the ASHP.

6. Secondary Chilled Water Pumps
   a. Secondary CHW pumps shall obey lead/lag guidelines outlined in Paragraph
      3.13B.5.
   b. Enable lead secondary CHW pump when any ASHP CHW bypass valve is
      commanded closed.
   c. Stage up when pumps reach 80% speed for more than 3 min.
   d. Stage down when pumps fall to 40% speed.
   e. When any pump is proven on, pump speed shall be controlled to maintain differential
      pressure.
   f. All pumps receive the same speed signal when multiple pumps are running.

7. Performance Monitoring
   a. Total plant power. Calculate total plant power as the sum of ASHP power and pump
      power.
   b. Summary Data. For each ASHP and total plant, statistics shall be retained and
      displayed on graphic for runtime, average actual efficiency (kW/ton), and average
      demand (tons) and load (ton-hours). Show on ASHP plant graphic: instantaneous
      values, year-to-date totals/averages and previous-year totals/averages.

8. Alarms
   a. Maintenance interval alarm when pump has operated for more than 1500 hours:
      Level 4. Reset interval counter when alarm is acknowledged.
   b. Maintenance interval alarm when ASHP has operated for more than 1000 hours:
      Level 4. Reset interval counter when alarm is acknowledged.
   c. High ASHP leaving chilled water temperature (more than 5°F above setpoint) for
      more than 15 minutes when ASHP has been enabled for longer than 15 minutes:
      Level 3
   d. Pump alarm is indicated by the status input being different from the output command
      after a period of 15 seconds after a change in output status.
      1) Commanded on, status off: Level 2
      2) Commanded off, status on: Level 4

P. Air Cooled Hot Water Plant

1. Parameters
   a. Temperature Setpoints
      1) HWSTmax, the highest hot water supply temperature setpoint
   b. Minimum Flow Setpoint
      1) HW-MinFlowSP, the design minimum HHW plant water flowrate as
         recommended by the manufacturer
   c. Capacity
      1) Qdesign, design plant capacity = total capacity of all ASHP
      2) Qstage, design capacity in KBtu/h for each stage
3) HWFdesign, design primary loop flow = total capacity of all HW pumps

d) HW Pump DP setpoint
   1) HW-DPmax = as determine under 230593 Testing, Adjusting and Balancing.

2. Plant Enable/Disable
   a. The ASHP plant shall include an enabling schedule that allows operators to lock out
      the plant during off-hours, e.g. to allow off-hour operation of HVAC systems except
      the ASHP plant. The default schedule shall be 24/7 (adjustable).
   b. Enable the plant in the lowest stage when the plant has been disabled for at least
      15 minutes and:
         1) Number of ASHP plant Requests > I (I = Ignores shall default to 0, adjustable), and
   c. ASHP HHW Staging
      a. ASHPs shall obey lead/lag control guidelines outlined in Paragraph 3.13B.5.
      b. If an ASHP is in alarm, pull that unit out of rotation and annunciate at the front end.
      c. The ASHP factory controls will manage any internal compressor stages that are
         internal to that unit. BMS to send enable command to the factory controls with
         hardware connection when the load in the secondary loop exceeds the capacity of
         a given unit.
      d. \( Q_{\text{required}} \) is calculated based on secondary flow btu meter. \( Q_{\text{required}} \) used in logic shall
         be a 5-minute rolling average of instantaneous values sampled at a minimum of
         every 30 seconds to prevent short cycling of ASHP.
      e. When a stage up or stage down transition is initiated, hold \( Q_{\text{required}} \) fixed at its last
         value until the longer of the successful completion of the stage change (e.g. lag
         ASHP proven on) and 15 minutes.
      f. Stage up to a 2nd or 3rd ASHP when the current secondary load is 80% of the capacity
         available.
      g. Stage down to fewer ASHP when current load is at 40% of available capacity.

4. Hot Water Plant Reset for Zones
   a. Differential Pressure Controlled Loops: heating hot water supply temperature
      setpoint HHWsp and pump differential pressure setpoint HHW-DPsp shall be reset
      based on the current value of the logic variable called “HHW Plant Reset” as shown
      below and described subsequently.
1) HHW Plant Reset shall be reset using Trim & Respond logic (see Guideline 36) with the following parameters as initial setpoints:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Any HHW Pump</td>
</tr>
<tr>
<td>SP₀</td>
<td>100%</td>
</tr>
<tr>
<td>SPₘᵟᵣᵢₙ</td>
<td>0%</td>
</tr>
<tr>
<td>SPₘᵃₓ</td>
<td>100%</td>
</tr>
<tr>
<td>Tₜ</td>
<td>15 minutes</td>
</tr>
<tr>
<td>T</td>
<td>5 minutes</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>Cooling HHWST Reset Requests</td>
</tr>
<tr>
<td>SPₘᵟᵢₙ</td>
<td>-2%</td>
</tr>
<tr>
<td>SPₘᵉˢ</td>
<td>+3%</td>
</tr>
<tr>
<td>SPₘᵉˢ-ᵐᵃₓ</td>
<td></td>
</tr>
</tbody>
</table>

2) Note: the initial setpoint is for HHW to be at max with max pumping.
3) Initially HHWST-min = as scheduled
4) HHWST-max = 5 degrees lower. Note: the control valves at the VAV boxes are all based on having constant temperature. If the HHW reset is too aggressive the zone valves will “hunt” or struggle to maintain setpoint.
5) HHWST Plant Reset loop shall be enabled when the plant is enabled and disabled when the plant is disabled.
6) When a plant stage change is initiated, HHW Plant Reset logic shall be disabled and value fixed at its last value for the longer of 15 minutes and the time it takes for the plant to successfully stage.

5. Primary Hot Water Pumps
a. These are controlled in fully the OEM controller on the ASHP.

6. Secondary Hot Water Pumps
   b. Enable lead secondary hot water pump when any ASHP isolation valve is commanded open. Disable the lead hot water pump when all ASHP isolation valves are commanded closed.
   c. Stage up when pumps reach 80% speed for more than 3 min.
   d. Stage down when pumps fall to 40% speed.
   e. When any pump is proven on, pump speed shall be controlled to maintain differential pressure.
   f. All pumps receive the same speed signal when multiple pumps are running.

7. Alarms
   a. Maintenance interval alarm when pump has operated for more than 1500 hours as indicated by the Staging Runtime: Level 4. Reset the Staging Runtime interval counter when alarm is acknowledged.
   b. Maintenance interval alarm when ASHP has operated for more than 2000 hours as indicated by the Staging Runtime: Level 4. Reset the Staging Runtime interval counter when alarm is acknowledged.
   c. ASHP alarm: Level 2
   d. Low ASHP leaving hot water temperature (more than 15°F below setpoint) for more than 15 minutes when ASHP has been enabled for longer than 15 minutes: Level 3
   e. Pump alarm is indicated by the status input being different from the output command after a period of 15 seconds after a change in output status.
      1) Commanded on, status off: Level 2
      2) Commanded off, status on: Level 4

3.14 MISCELLANEOUS ALARMS
   1. Points in Hand (Operator Override) via Workstation command (including name of operator who made the command) or via supervised HOA switch at output: Level 4
   2. Equipment alarm (for equipment with alarm contacts such as VFDs, AC units): Level 2
   3. Failure or disconnection of a sensor as indicated by signal widely out of range: Level 2.
   4. Panel or LAN failure: Level 2
   5. Loss of communication with any device via Gateway (e.g. VFD) for more than 30 seconds: Level 2 (alarm shall indicate which specific device is not responding).
   6. Electrical switchgear alarm (from Electrical Power System gateway): Level 2

3.15 SYSTEM COMMISSIONING
   A. Sequencing. The following list outlines the general sequence of events for submittals and commissioning:
      1. Submit Submittal Package 0 (Qualifications) and receive approval.
      2. Submit Submittal Package 1 (Hardware and Shop Drawings) and receive approval.
      3. Initiate installation of BAS hardware, devices and wiring.
      4. Develop point database and application software.
      5. Simulate sequencing and debug programming off-line to the extent practical.
      6. Submit Submittal Package 2 (Programming and Graphics) and receive approval.
      7. Complete installation of BAS hardware, devices and wiring.
      8. Install point database and application software in field panels.
      9. Submit Submittal Package 3 (Functional Testing) and receive approval.
10. Perform BAS Pre-functional Tests (start up, calibration and tuning) and submit completed Pre-functional Test Forms for approval.

11. Field test application programs prior to functional testing.


13. Prepare and initiate commissioning Trend Logs.

   a. Some tests may not be possible due to weather conditions. These tests may be deferred to post-occupancy period.

15. Assist in TAB tests and determining setpoints as specified in Section 230593 Testing, Adjusting and Balancing.


17. Submit Package 4 (Training Materials) and receive approval.

18. Receive BAS Functional Test Report approval and approval to schedule Demonstration Tests.


21. Train Owner personnel on BAS operation and maintenance.

22. Substantial Completion

23. Submit Package 5 (Post-Construction Trend Logs) in format specified for review and approval.

24. Receive approval of successful Trend Log tests, or retest as required.

25. Complete all items in Completion Requirements per Paragraph 1.9.

26. Provide administration level password access to the Owner.

27. Final Acceptance


29. Prepare and initiate post-occupancy Trend Logs.

30. Update all software as specified.

31. End of Warranty Period

B. Test Documentation

1. Pre-functional Tests
   a. Prepare forms to document the proper startup of the BAS components.
   b. All equipment shall be included on test forms including but not limited to
      1) Wiring: End-to-end checkout of all wiring at terminations. Power to all controllers and actuators. Confirmation of emergency power where specified.
      2) Digital Outputs: Proper installation, normal position, response to command at CU
      3) Digital Inputs: Proper installation, device test, response at CU
      4) Analog Outputs: Proper installation of devices, verification of maximum and minimum stroke.
      5) Analog Inputs: Proper installation of sensors, calibration
      6) Panels: Confirmation of location, power source (electrical circuit used), confirmation of emergency power where specified.
      7) Alarms and Safeties: Verification of alarm routing to all specified devices and correct hierarchy. Example: confirm alarm routing to cell phones, email, servers, remote workstations. Confirm that appropriate alarm levels are routed to appropriate devices.
      8) Loop Tuning: Document setting of P/I parameters for all loops, chosen setpoints, time delays, loop execution speed.

c. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.
d. Submit forms for approval in Submittal Package 3.
e. Complete work, document results on forms, and submit for approval as Pre-Functional Test Report.

2. Functional Tests

a. Owner's Representatives will prepare functional testing forms after Submittal Package 2 has been reviewed and approved. Tests will be designed to test all sequences in a formal manner with simulations and expected outcomes.
b. Review tests and recommend changes that will improve ease of testing or avoid possible system damage, etc.
c. Adapt forms from Owner's Representative into electronic format. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.
d. Submit forms for approval in Submittal Package 3.
e. Complete work, document results on forms, and submit for approval as Functional Test Report.

C. Assist Commissioning Provider/Coordinator as specified in Section 019100 Commissioning, including attending commissioning meetings.

D. Coordinate with Work specified in Section 230800 Mechanical Commissioning and Division 26 Electrical Commissioning.

E. Pre-functional tests

1. General

a. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
b. Verify proper electrical voltages and amperages and verify that all circuits are free from faults.
c. Verify integrity/safety of all electrical connections.
d. Verify that shielded cables are grounded only at one end.
e. Verify that all sensor locations are as indicated on drawings and are away from causes of erratic operation.

2. Digital Outputs

a. Verify that all digital output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

3. Digital Inputs

a. Adjust setpoints, where applicable.

1) For current switches used as status on fans, adjust current setpoint so that fan status is OFF when fan discharge damper (if present) is fully closed and when belt is broken (temporarily remove belt).
2) For current switches used as status on pumps, adjust current setpoint so that pump status is OFF when pump is dead-headed (temporarily close discharge valve).
3) For differential pressure sensors on pumps and fans, set so that status is on when pump operating with all valves open (out on its curve).
4. **Analog Outputs**
   a. Verify start and span are correct and control action is correct.
   b. Check all control valves and automatic dampers to ensure proper action and closure. Make any necessary adjustments to valve stem and damper blade travel.
   c. Check all normal positions of fail-safe actuators.
   d. For outputs to reset other manufacturer’s devices (for example, ASHP setpoint) and for feedback from them, calibrate ranges to establish proper parameters.

5. **Analog Input Calibration**
   a. Sensors shall be calibrated as specified on the points list. Calibration methods shall be one of the following:
      1) Factory: Calibration by factory, to standard factory specifications. Field calibration is not required.
      2) Handheld: Field calibrate using a handheld device with accuracy meeting the requirements of Paragraph 2.10.
   b. The calibrating parameters in software (such as slope and intercept) shall be adjusted as required. A calibration log shall be kept and initialed by the technician indicating date and time, sensor and hand-held readings, and calibration constant adjustments and included in the Pre-functional Test Report.
   c. Inaccurate sensors must be replaced if calibration is not possible.

6. **Alarms and Interlocks**
   a. A log shall be kept and initialed by the technician indicating date and time, alarm/interlock description, action taken to initiate the alarm/interlock, and resulting action, and included in the Pre-functional Test Report.
   b. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
   c. Coordinate with Division 26 to test fire and life safety systems alarm contacts.
   d. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
   e. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

7. **Variable Frequency Drive Minimum Speed**
   a. Minimum speed for VFD-driven fans and pumps shall be determined in accordance with this Paragraph. Tests shall be done for each piece of equipment, except that for multiple pieces of identical equipment used for identical applications, only one piece of equipment need be tested with results applied to all. Note that for fans and pumps, there is no minimum speed required for motor cooling. Power drops with cube of speed, causing motor losses to be minimal at low speeds.
   b. This work shall be done only after fan/pump system is fully installed and operational.
   c. Determine minimum speed setpoint as follows:
      1) Start the fan or pump.
      2) Manually set speed to 6 Hz (10%) unless otherwise indicated in control sequences. For cooling towers with gear boxes, use 20% or whatever minimum speed is recommended by tower manufacturer.
      3) Observe fan/pump in field to ensure it is visibly rotating.
         a) If not, gradually increase speed until it is.
      4) The speed at this point shall be the minimum speed setpoint for this piece of equipment.
      5) Record minimum speeds in log and store in software point as indicated in Guideline 36.
8. Tuning

a. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the Pre-functional Test Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted).

<table>
<thead>
<tr>
<th>Controlled Variable</th>
<th>Control Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duct Pressure</td>
<td>±0.1 inches w.g.</td>
</tr>
<tr>
<td>Building and relief plenum</td>
<td>±0.01 inches w.g.</td>
</tr>
<tr>
<td>Airflow and water flow</td>
<td>±10%</td>
</tr>
<tr>
<td>Space Temperature</td>
<td>±1.5°F</td>
</tr>
<tr>
<td>Condenser Water Temperature</td>
<td>±2°F</td>
</tr>
<tr>
<td>Chilled Water Temperature</td>
<td>±1°F</td>
</tr>
<tr>
<td>Hot Water Temperature</td>
<td>±3°F</td>
</tr>
<tr>
<td>Duct Temperature</td>
<td>±2°F</td>
</tr>
<tr>
<td>Water Differential Pressure</td>
<td>±1.5 psi</td>
</tr>
<tr>
<td>Others</td>
<td>±2 times reported accuracy</td>
</tr>
</tbody>
</table>

9. Interface and Control Panels

a. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the Record Drawings.

b. Ensure that terminations are safe, secure and labeled in accordance with the Record Drawings.

c. Check power supplies for proper voltage ranges and loading.

d. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.

e. Check for adequate signal strength on communication networks.

f. Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.

g. Ensure that buffered or volatile information is held through power outage.

h. With all system and communications operating normally, sample and record update and annunciation times for critical alarms fed from the panel to the Operator Interface.

i. Check for adequate grounding of all BAS panels and devices.

10. Operator Interfaces

a. Verify that all elements on the graphics are functional and are properly bound to physical devices or virtual points, and that hot links or page jumps are functional and logical.

b. Verify that the alarm logging, paging, emailing etc. are functional and per requirements.

F. Testing, Adjusting, and Balancing (TAB) Coordination

1. Coordinate with Work performed under Section 230593 Testing, Adjusting, and Balancing. Some balancing procedures require the BAS to be operational and require Contractor time and assistance.

2. Calibration Software
a. Software shall be provided free of charge on at least a temporary basis to allow calibration of terminal box airflow controls and other Work specified under Section 230593 Testing, Adjusting, and Balancing.
b. Software shall be provided for installation on POT(s) provided by Others or Contractor shall loan a POT or handheld device with software installed for the duration of Work specified under Section 230593 Testing, Adjusting, and Balancing.
c. Provide sufficient training to those performing Work specified under Section 230593 Testing, Adjusting, and Balancing to allow them to use the software for balancing and airflow calibration purposes. Contractor shall include a single training session for this purpose.

3. Setpoint Determination
   a. Perform pre-functional tests described in Paragraph 3.15B.1 before assisting in setpoint determination.
   b. Coordinate with Work performed under Section 230593 Testing, Adjusting, and Balancing to determine fan and pump differential pressure setpoints, outdoor air damper minimum positions and DP setpoints, etc. as indicated in Section 230593 Testing, Adjusting and Balancing.

G. Functional Tests
   1. Test schedule shall be coordinated with the Commissioning Provider, Commissioning Coordinator, and Owner’s Representative.
   2. Functional tests may be witnessed by Owner’s Representative at the Owner’s option.
   3. All approved Functional Tests shall be conducted by the Contractor with results confirmed and signed by the Contractor’s start-up technician.
   4. Test documentation shall be submitted to the Owner for review and approval.

H. Demonstration Test
   1. Demonstration tests consist of a small representative sample of functional tests and systems randomly selected by the Commissioning Provider. Tests will be designed to occur over no longer than 2 working days.
   2. Schedule the demonstration with the Commissioning Provider and Owner’s Representative at least 1 week in advance. Demonstration shall not be scheduled until the Functional Test Report has been approved.
   3. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor-supplied personnel shall be those who conducted the Functional tests or who are otherwise competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems.
   4. The system will be demonstrated following procedures that are the same or similar to those used in the Pre-Functional and Functional Tests. The Commissioning Provider will supply the test forms at the site at the start of the tests.
   5. Demonstration tests may be witnessed by Owner’s Representative at the Owner’s option.
   6. Contractor shall conduct tests as directed by and in the presence of the Commissioning Provider and complete test forms. Completed forms shall be submitted as the Demonstration Test Report to the Commissioning Provider after tests are complete.
   7. Demonstration Tests shall be successfully completed and approved prior to Substantial Completion.

I. Trend Log Tests
   1. Trends shall be fully configured to record and store data to the server for the points and at the interval listed in Paragraph 2.11 as follows:
      a. Commissioning: Configure trends prior to functional testing phase. Retain configuration until post-construction commissioning trend review has been
completed successfully and accepted by the Owner’s representative. Trends shall be deactivated after acceptance.

b. Continuous: After system acceptance, configure trends for the purpose of long-term future diagnostics. Configure trends to overwrite the oldest trends at the longest interval possible without filling the server hard disk beyond 80%.

2. Post-Construction Trend Test

a. Trend logging shall not commence until Demonstration Tests are successfully completed.

b. Hardware Points. Contractor shall configure points to trend as indicated in the Commissioning Trend column listed in Paragraph 2.11 points.

c. Software Points. Include the following in trends of systems and zones whose hardware points are being trended as called for above. Time interval shall be the same as associated hardware point.

1) All setpoints and limits that are automatically reset, such as supply air temperature and fan static pressure setpoints, plus the points that are driving the reset, such as zone level cooling and static pressure requests

2) All setpoints that are adjustable by occupants

3) Outputs of all control loops, other than those driving a single AO point that is already being trended

4) System mode points (e.g. Warm-up, Occupied, etc.)

5) Global overrides such as demand shed signals

6) Calculated performance monitoring points, such as ASHP efficiency

d. Submit for review and approval by the by Commissioning Provider a table of points to be trended along with trend intervals or change-of-value a minimum of 14 days prior to trend collection period.

e. Trends shall be uploaded to the CSS in data format specified in Paragraph 2.11C.3.

f. Trend logs of all points indicated above shall be collected for a 4-week Trend Period.

g. At the completion of the Trend Period, data shall be reviewed by the Contractor to ensure that the system is operating properly. If so, data shall be submitted to the Owner in an electronic format agreed to by the Owner and Contractor (such as flash drive or via direct access to the CSS via the internet).

h. Data will be analyzed by the Commissioning Provider.

i. The system shall be accepted only if the trend review indicates proper system operation without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. If any but very minor glitches are indicated in the trends, steps f to h above shall be repeated for the same Trend Period until there is a complete Trend Period of error free operation.

j. After successfully completing the Post-Construction Trend Tests, the Contractor shall configure all points to trend as indicated in the Continuous Trend column listed in Paragraph 2.11 points list.

J. Remedial Work

1. Repair or replace defective Work, as directed by Owner’s Representative in writing, at no additional cost to the Owner.

2. Restore or replace damaged Work due to tests as directed by Owner’s Representative in writing, at no additional cost to the Owner.

3. Restore or replace damaged Work of others, due to tests, as directed by Owner’s Representative in writing, at no additional cost to the Owner.

4. Remedial Work identified by site reviews, review of submittals, demonstration test, trend reviews, etc. shall be performed to the satisfaction of the Owner’s Representative, at no additional cost to the Owner.
5. Contractor shall compensate Owner’s Representatives and Commissioning Provider on a time and material basis at standard billing rates for any additional time required to witness additional demonstration tests or to review additional BAS trends beyond the initial tests, at no additional cost to the Owner.

3.16 TRAINING

A. Coordinate schedule and materials with Commissioning Authority.

B. Interim Training
   1. Provide minimal training so the operating staff can respond to occupant needs and other operating requirements during start-up and commissioning phase.

C. Formal Training
   1. Training shall be conducted after all commissioning is complete and systems are fully operational.
   2. ALC Training
      a. It may be assumed that College building engineers have been previously trained on the existing ALC system.
      b. Include training on ALC system operations only for new features installed at CSS/OWS as a part of this project.
   3. Jobsite Training
      a. Include 40 hours total of on-site training to assist personnel in becoming familiar with job-specific issues, systems, control sequences, etc.
      b. College shall be permitted to videotape training sessions.
   4. Training may be in non-contiguous days at the request of the College.
   5. During the warranty period, provide unlimited telephone support for all trained operators.

END OF SECTION
SECTION 250413 - COMMON SUBMITTAL REQUIREMENTS FOR INTEGRATED AUTOMATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project’s environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER’S AND GENERAL CONTRACTOR’S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect’s staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect’s notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.
   1. Action Code for Information Only:
      a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
   1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be ‘broken out’ for special handling. Arrange submittals accordingly.

C. Submittal Numbering
1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS
   A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.
   B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.
   C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
      1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.
   D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 253000 - BUILDING AUTOMATION SENSORS AND CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. As part of the Work performed under Section 25 50 00 “Building Automation Hardware and Networking”, the DDC Contractor shall furnish control devices, instruments, meters and sensors in accordance with this Section. Provide all control devices, instruments, meters and sensors required for a fully functional DDC System capable of fully executing the specified Sequences of Operations.

B. DDC Contractor shall install these products or deliver them to contractors of other trades for installation under the direction of the General Contractor and in accordance with the coordination requirements of Section 255000.

C. All General Conditions of Section 255000 shall apply to the Work done under this Section.

D. Except as specifically allowed in this Section, all networked control devices shall be ANSI/ASHRAE 135 native BACnet devices.

1. All DDC devices shall be tested, certified, clearly stamped and listed by the BACnet Testing Laboratories (BTL) prior to the bid date for this Project.

2. The BACnet operating stack must be embedded directly in each individual DDC device at the media access controller level and in all operator interface and configuration applications.

3. Communication gateways, bridges, and protocol translators are permitted only under the following conditions:
   a. Protocol translators as required to communicate to existing building systems or legacy control systems.
   b. Equipment-specific gateways and dedicated controllers that are supplied, recommended or endorsed by the manufacturer of the equipment they are to control.
   c. Gateways shall allow the DDC System to read all readable object properties and write to all writeable object properties using standard BACnet services.
   d. Gateways shall provide all BACnet communication services and features described in “BACnet Gateways” under Network Communication Devices in Part 2 of Section 25 50 00.

E. Section includes

1. Actuators
2. Control Valves
4. Sensors for Air: Temperature, Pressure, and Flow
5. Thermostats
6. Space Sensors: Temperature, CO₂, CO, Humidity
7. Outdoor Sensors: Temperature, Humidity, Wind Speed, Radiation
8. Switches and Status Indicators
9. Time Clocks
1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01, apply to this Section, except as specifically noted in this Section.

B. Product and installation requirements for electrical wiring and devices in Division 26 and Division 27 apply to this Section, except as specifically noted in this document.

C. Related Specifications
   1. Section 230000 “HVAC General Requirements”
   2. Section 233300 “Air Duct Accessories”
   3. Section 255000 “Building Automation Hardware and Networking”
   4. Section 255005 “Laboratory Monitoring & Control System”

1.3 DEFINITIONS

A. See Definitions in Section 255000.

1.4 CODES AND STANDARDS

A. Workmanship, materials and equipment together with the resultant complete and operational DDC System shall be in compliance with the Authorities Having Jurisdiction (AHJ) for the project and the most restrictive of applicable local, state and federal codes and ordinances in cooperation with these plans and specifications.

B. At a minimum, the installation shall comply with the applicable sections of the current editions in effect thirty (30) days prior to receipt of bids of the following codes:
   1. ANSI/ASHRAE Standard 135: Data Communication Protocol for Building Automation and Control Networks (BACnet)
   3. California Code Title 24, if Project is located in California
   4. National Electric Code (NEC) with all state and local amendments
   5. Telecommunications Industry Association (TIA):
      a. ANSI/TIA-568-C.0: Generic Telecommunications Cabling for Customer Premises
      b. ANSI/TIA-568-C.1: Commercial Building Telecommunications Cabling Standards
      c. ANSI/TIA-568-C.2: Balanced Twisted Pair Telecommunications Cabling and Components
      d. ANSI-TIA-607-B: Generic Telecommunications Bonding and Grounding for Customer Premises

1.5 SUBMITTALS AND COMPLETION REQUIREMENTS

A. Submittal schedule and requirements shall be as described under Submittals in Part 1 of Section 255000

B. Closeout requirements shall be as described under Completion Requirements in Part 1 of Section 255000.

C. All products and devices furnished under this Section shall be submitted for review and approval as described in Section 25 50 00. All conditions of Section 25 50 00 apply, including procedures for submitting substitution and documenting product deviations from specification.
1.6 OWNERSHIP AND WARRANTY

A. All materials, hardware and software associated with the Work performed under Section 25 50 00 and this section shall be provided to the Owner, and shall be owned by or licensed to the Owner. This includes all materials required to support a later expansion of the DDC System, as detailed in Section 25 50 00.

B. All products provided under this Section are subject to the DDC System warranty and warranty maintenance conditions as described in Section 25 50 00.

PART 2 - PRODUCTS

2.1 GENERAL

A. It shall be the DDC Contractor’s responsibility to ensure that all control devices are compatible with controller hardware, firmware, and software.

B. All networked devices provided under this Section shall be native BACnet devices as specified in Paragraph 1.1D.

C. Provide signal conditioning for all instruments and sensors devices as recommended by device manufacturer and as required for proper operation in the system.

D. Where signal conditioners, signal boosters, signal repeaters, or other devices are required for proper interface to controllers, DDC Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.

E. Except as specifically noted in this Section, transmitters are assumed to be two-wire type with power supplied by the connected controller. If the controller is not compatible with two-wire transmitters, if the transmitter is to connect to more than one controller, or if length of wire to the controller would compromise accuracy, DDC contractor shall provide a four-wire transmitter and power supply as required.

F. Environmental Conditions

1. Unless otherwise indicated, all components provided under Division 25 shall operate under ambient environmental conditions of 32°F to 122°F dry-bulb and 10% to 90% relative humidity, non-condensing as a minimum.

   a. It is the DDC Contractor’s responsibility to identify locations subject to more extreme conditions, particularly rooftop and outdoor installations, and provide products suitable for those locations.

2. Sensors and control elements shall be constructed of material suitable and rated for the media sensed under the ambient environmental temperature, pressure, humidity, and vibration conditions encountered for the installed location.

G. Accuracy

1. Accuracy shall include combined effects of nonlinearity, repeatability and hysteresis.
2. Accuracy of the instrument shall be equal or better than the requirements of specific devices in this Section.
3. Overall end-to-end accuracy of installed sensors shall satisfy the performance requirements in Section 25 50 00. DDC Contractor shall select sensors, wiring method, transmitters, A/D conversion bits, etc. to provide required accuracy.
4. Note that accuracy performance requirements in Section 25 50 00 are generally given in absolute deviation (e.g. ±X°F) or in percentage of sensor span (i.e. from minimum to maximum value that will be measured in the application). Most sensors are specified in terms of sensor range/scale (i.e. the capabilities of sensor). If a sensor range is much larger than its span, a higher accuracy over range will be required to meet the required accuracy over span. DDC Contractor shall select sensors accordingly.

H. Products requiring an electrical connection shall be listed and classified by Underwriters Laboratories Inc. (UL), as suitable for the purpose specified and indicated.

2.2 ACTUATORS

A. General, All Actuators

1. Actuator shall have microprocessor based motor controller providing electronic cut off at full open/closed.
   a. Actuator shall have internal current limiting circuit or digital motor rotation sensing circuit to prevent motor burnout.
   b. End switches to deactivate the actuator at the end of rotation or use of magnetic clutches are not acceptable.

2. Actuator shall emit no audible noise while holding position.
3. Moving noise shall be inaudible through a T-bar ceiling.
4. Actuator shall be capable of being mechanically and electrically paralleled to increase torque where required.
5. Actuator shall clearly indicate current position.
6. Provide pre-wired with conduit fitting and minimum three-foot electrical cable. It shall not be necessary to open actuator housing to connect power to actuator.
7. For fail-safe (fail-open or fail-closed) applications, include mechanical spring return or capacitor return mechanism built into actuator housing. All fail-safe actuators shall be capable of reversing return direction by changing mounting orientation, or by selection switch.
8. Include external gear release to allow manual positioning of unpowered actuator.
    a. Spring return actuators with more than 60 inch-pound torque shall have a manual crank for this purpose.
    b. Large industrial actuators (e.g. for butterfly valves) shall be equipped with a hand wheel to permit operation of the valve when the actuator is unpowered.
9. Only where indicated on Contract Drawing control schematics, actuator shall include the following:
    a. Analog position feedback signal from actuator output. The use of a separate potentiometer for position feedback is not acceptable.
    b. Limit (end) position feedback. Switches must be built into actuator and constructed so as not to require a separate electrical ground. Switch must be adjustable to match stroke range. The use of separate (bolt-on or clip-on) actuator auxiliary switches is not acceptable. The use of separate mechanical position switches (e.g. on dampers) is not acceptable unless specifically called for on drawings. Switch must prove at 0% and 100% of the field-adjusted (not maximum) stroke.
10. Power Requirements
   a. 24 VAC/DC actuators shall operate on Class 2 wiring.
   b. 24 VAC actuators shall not require more than 10 VA.
   c. 120 VAC actuators shall not require more than 10 VA.
   d. 240 VAC actuators shall not require more than 11 VA.

11. Entire actuator shall be UL 873 listed.

12. Provide with enclosure per requirements of Section 25 50 00.

13. Design life of at least 60,000 full cycles at full torque

14. Provide with manufacturer’s 5-year warranty.

B. Modulating Actuators, All Types

1. Actuators shall accept a 0-10 VDC or 0-20 mA control signal and provide a 2-10 VDC or 4-20 mA operating range.

2. Actuators shall have positive positioning circuit so that controlled device is at same position for a given signal regardless of operating differential pressure.

3. Actuators shall have true proportional position control. Floating point actuators are not acceptable, except for terminal unit damper actuators which may be floating point type if both of the following conditions are met:
   a. Actuator provides position feedback as an analog input to the terminal unit controller.
   b. Position end switches recalibrate damper position feedback when end of stroke is reached. Recalibration shall be automatic and transparent to user.

4. All modulating actuators shall have a built-in external switch to reverse direction of rotation.

C. Damper Actuators

1. Actuator shall clamp directly to damper shaft. The clamp shall be all steel of a V-bolt design with associated V-shaped, toothed cradle for cold weld attachment.
   a. Single bolt or set screw type fasteners are not acceptable.
   b. Aluminum clamps are not acceptable.

2. For each individual damper section, the actuator shall be direct coupled to shaft, without connecting linkage.

3. Select actuator torque and/or quantity to satisfy all of the following requirements:
   a. Opposed blade dampers: Minimum 7 inch-pounds per ft² of damper.
   b. Parallel blade dampers: Minimum 5 inch-pounds per ft² of damper.
   c. Terminal unit dampers: Minimum 45 inch-pounds.
   d. Sufficient to provide smooth proportional control with air velocities 20% greater than maximum design velocity.
   e. As required by blade and/or edge seals, per damper manufacturer.
   f. The total damper area operated by an actuator shall not exceed 80% of the manufacturer’s maximum area rating.

D. Valve Actuators

1. Actuators shall be specifically designed for integral mounting to valves without external couplings.

2. Modulating valve actuators shall have minimum rangeability of 50 to 1.

3. Actuators for 2-way valves shall have sufficient torque for
   a. Tight closing against 125% of system pump shut-off head
   b. Modulating duty against 90% of system pump shut-off head

4. Actuators for 3-way valves shall have sufficient torque for tight closing against twice (200%) of the full open differential pressure for which they are sized.
E. Manufacturers (alphabetical order)
   1. Belimo
   2. Delta
   3. Invensys
   4. Johnson Controls
   5. Siemens
   6. Or equal

2.3 CONTROL VALVES

A. General
   1. DDC Contractor shall provide type of valve per this specification, unless specifically indicated otherwise on Contract Drawings.
   2. Three-way valves are only to be used where specifically shown on Contract Drawings. Unless otherwise indicated, all control valves shall be two-way valves.

B. Valve Size and Selection
   1. Valves for modulating service shall be selected as follows:
      a. DDC Contractor is responsible for selecting valve Cv and size unless otherwise specified on Contract Drawings. Use the highest Cv that will provide good control, while observing the following limits:
         1) Minimum full-open pressure drop: equal to half the pressure drop of coil or heat exchanger
         2) Maximum full-open pressure drop
            a) Hot water coil: 2 PSI
            b) Chilled water coil: 5 PSI
            c) Chiller head pressure control: 1 PSI
         3) Cv shall be greater than 1.0, to avoid clogging, unless protected by a strainer.
      b. Valve size shall be as close as possible to pipe size while providing required Cv.
      c. If good control cannot be achieved while observing these limits, Contractor shall ask for clarification.
   2. Valves for two-position service shall equal pipe size unless otherwise indicated on Contract Drawings.
   3. Minimum pressure rating for valve assemblies shall depend on application:
      a. Chilled or condenser water: 125 PSI at 60°F, or higher as required by application
      b. Hot water: 125 PSI at 250°F, or higher as required by application
      c. Steam: 125 PSI at 350°F, or higher as required by application
   4. Valve type shall depend on size and service. Unless otherwise noted on Contract Drawings, select valves as follows:
      a. Modulating, 6 inches and less: Ball valve, equal percentage or modified equal percentage characteristic.
      b. Modulating, 8 inches and greater: Butterfly valve, equal percentage characteristic.
      c. Chiller head pressure control: Butterfly valve, equal percentage characteristic.
      d. Two-position service: Full-port ball valve without characterizing disc, or butterfly valve with linear or quick-opening characteristic.

C. Ball Type
   1. Body: Nickel plated forged brass
   2. Trim: Brass or bronze
3. Ball: Stainless steel
4. Stem: Stainless steel
5. Blowout proof stem design
   a. Glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 PSI rating (2-way valves) or 400 PSI rating (3-way valves).
   b. Stem packing shall consist of 2 lubricated O-rings designed for on-off, floating, or modulating service and requiring no maintenance.
   c. Thermal break in stem
6. Guaranteed leak-free for 200,000 full stroke cycles
7. Valves for modulating service shall:
   a. Be specifically designed for modulating duty in control application
   b. Provide equal percentage or modified equal percentage characteristics
   c. Have characterizing disk held securely by keyed ring
8. Valves for two-position service shall be full bore and equal to pipe size, with no characterizing disc.
9. Manufacturers (alphabetical order)
   a. Belimo
   b. Delta
   c. Invensys
   d. Siemens
   e. Or equal

D. Butterfly Type
1. Body: Epoxy-coated cast or ductile iron, full lug, extended neck
2. Seat: Replaceable, non-collapsible, phenolic backed EPDM or PTFE
3. Disc: Polished aluminum bronze or stainless steel with machined edge, mechanically locked to shaft. Sanded cast disc is not acceptable.
4. Bearings: Bronze or stainless steel
5. Stem: 410 or 416 stainless steel with mechanical retention, supported at three locations with PTFE bushings for positive shaft alignment
6. Bubble-tight shutoff at rated differential pressure
7. Valves for modulating service shall have equal percentage characteristic.
8. Valves for two-position service shall have linear or quick opening characteristic.
9. Manufacturers (alphabetical order)
   a. Belimo
   b. Delta
   c. Dezurik
   d. Invensys
   e. Jamesbury
   f. Keystone
   g. Siemens
   h. Or equal

E. Globe Type
1. Not to be used. Globe valves are not acceptable for hydronic applications.

F. Gate Type
1. Not to be used. Gate valves are not acceptable for any application.
2.4 WATER TEMPERATURE SENSORS

A. Immersion Type

1. Thermistor or RTD type sensor, suitable for temperatures being sensed. Sensor full scale shall not be less than 125% of expected range, as indicated on Contract Drawing control schematics or in sequences of operations (Section 259000).

2. ¼” stainless steel probe, double encapsulated sensor, thermowell mounted, with enclosure suitable to location.

3. Accuracy as required to satisfy Paragraph 2.1F and Section 25 50 00
   a. Inaccuracy due to wire resistance shall in no case exceed 0.5°F. Select wire gauge and/or provide transmitter if necessary to meet this requirement.

4. Drift shall not exceed 0.3°F per year.

5. Sensor shall not require recalibration for at least five years.

6. Temperature transmitter
   a. Provide when required for compatibility with controller or to meet specified accuracy.
   b. Output: 4-20mA linearly across specified temperature range
   c. Include non-interactive zero and span adjustment
   d. Accuracy: ±0.1°F across sensor range

7. Provide with thermowell
   a. One-piece machined brass or stainless steel
   b. With lagging extension equal to pipe insulation thickness
   c. Permits sensor removal from operating system
   d. Rated for maximum system operating pressure, temperature and fluid velocity

8. Manufacturers (alphabetical order)
   a. Automated Logic Corp.
   b. Building Automation Products Inc.
   c. Kele Associates
   d. Mamac
   e. Or equal

B. The use of direct immersion or strap-on type sensors is not acceptable.

2.5 WATER PRESSURE SENSORS

A. General

1. Stainless steel welded construction.
   a. All wetted surfaces shall be stainless steel
   b. Brazed construction or the use of O-rings or mechanical interference fit to seal assemblies is not acceptable.

2. Two-wire transmitter, 4-20 mA output with non-interactive zero and span adjustments

3. Long-term stability 0.5% full scale per year

4. Sensor shall be fixed-range. Switch-selectable pressure range is not acceptable.

5. Select sensor based on expected range as shown on control drawings or as indicated in sequences of operations (Section 259000).
   a. For unidirectional sensors, the maximum of expected range (i.e. largest positive or negative reading) shall be no more than 75% of sensor full scale.
   b. For bidirectional sensors, expected range shall be between 25% and 75% of sensor full scale.
6. Pressure limits
   a. Rated pressure: by application
   b. Proof pressure: 2x rated pressure
   c. Burst pressure: 5x rated pressure

7. Temperature range suitable for application

8. Provide with valved "block and bleed" manifold allowing sensor to be isolated and vented. Vent ports shall be usable as test plugs for calibration.

B. Water, Absolute Pressure, General Purpose
   1. Fast response piezoresistive or capacitive sensor
   2. Device accuracy (at constant temp) ±0.5% full scale (see Paragraph 2.1F)
   3. Include temperature compensation
   4. Provide with 3-valve brass manifold
   5. Manufacturers (order of preference)
      a. Setra 209
      b. Kele P51 Series
      c. Or equal

C. Water, Differential Pressure, General Purpose
   1. Fast response capacitive sensor
   2. Single diaphragm wet-to-wet construction
   3. Device accuracy (at constant temp) ±0.25% full scale (see Paragraph 2.1F)
   4. Non-Linearity (BFSL method): ±0.22% full scale
   5. Hysteresis: 0.10% full scale
   6. Include temperature compensation
   7. Provide with 5-valve brass manifold
   8. Manufacturers (order of preference)
      a. Setra 230
      b. Or equal

2.6 WATER FLOW METERS, HIGH ACCURACY

A. General
   1. Flow sensor and signal converter shall be sold as a package by the same manufacturer.
   2. Install with isolation valves immediately upstream and downstream of meter. If isolation valves are by others, DDC Contractor shall coordinate installation with installing Trade. If hot-tapping an operating hydronic system, provide hot-tap isolation valve instead to enable sensor removal without water supply system shutdown.
   3. Install sensor in a location that provides sufficient lengths of straight pipe upstream and downstream of meter. Follow all manufacturer recommendations. If sufficient straight pipe is not available, notify Engineer of Record.
   4. All I/O points shown as hardwired on Contract Drawing control schematics must be hardwired. Points shown as networked may be transmitted as BACnet objects via network, or as hardwired I/O points.
   5. UL listed.
   6. NSF Drinking Water approval for domestic water applications.
B. Magnetic, Full Bore

1. Flow Sensor
   a. Full bore electromagnetic flow sensor
   b. Range suitable for application and design flows
   c. Flanged or grooved connections for pipe over 1” diameter; threaded connections acceptable for 1” diameter or less.
   d. Fully welded construction
   e. Stainless steel or Hastelloy C electrodes bonded to sensor tube without o-rings.
   f. Liner material shall be:
      1) Polypropylene, ebonite or EPDM for chilled or condenser water applications.
      2) Polypropylene only for hot or cold domestic water applications
      3) PTFE or PFA rated for 210°F for heating hot water applications.
   g. No moving parts

2. Signal Converter/Transmitter
   a. Provide four-wire, externally powered transmitter with non-interactive zero and span adjustments.
   b. Include alphanumeric display indicating current flow rate. Mount to flow sensor if readily visible; otherwise remote wall-mount in a readily visible location.
   c. Hardwired I/O (where required; see control schematics): Flow signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow).

3. Performance
   a. Flow velocity range: 0.04 - 33 FPS
   b. Accuracy shall be ±0.5% of actual reading from 3 to 30 FPS flow velocity, and ±0.015 FPS from 0.04 to 3 FPS.
   c. Accuracy shall be maintained over a turndown ratio of at least 10:1.
   d. Stability: 0.1% of rate over six months.
   e. Repeatability: ±0.1% of rate velocities > 3 FPS.
   f. NIST traceable factory calibration performed on accredited water flow test rig.

4. Manufacturers (order of preference)
   a. Onicon F-3000 series
   b. Siemens Sitrans FM Mag series
   c. Krohne Optiflux 2000 or 4000
   d. Sparling TigermagEP
   e. McCrometer UltraMag
   f. Or equal

C. Magnetic, Insertion Type

1. Flow Sensor
   a. Insertion electromagnetic flow sensor
   b. Meter shall have at least two sets of electrodes, with the flow reading based on the average across all electrodes.
   c. Stainless steel or Hastelloy C electrodes
   d. No moving parts

2. Include 'hot-tap' isolation valves to enable sensor removal without water supply system shutdown.
3. Signal Converter/Transmitter
   a. Adjustable zero and span, non-interactive.
   b. Hardwired I/O (where required, see control schematics): 0-10 V or 4-20 mA output for flow.

4. Performance
   a. Flow velocity range: 0.3 - 20 FPS
   b. Accuracy shall be ±1% of actual reading from .3 to 20 FPS flow velocity.
   c. Accuracy shall be maintained over a turndown ratio of at least 10:1.
   d. NIST traceable factory calibration performed on accredited water flow test rig.

5. Manufacturers (order of preference)
   a. Marsh MultiMag 284L
   b. McCrometer FPI Mag
   c. Onicon F-3500
   d. SeaMetrics EX100/200 Series
   e. Or equal

D. Ultrasonic, Inline
   1. Flow Sensor
      a. Ultrasonic type measuring flow by differential transit time
      b. Measurement by wetted direct-beam path. Clamp-on or indirect measurement is not acceptable.
      c. Range suitable for application and design flows
      d. Maximum 1.5 PSI pressure drop at design flow
      e. Flanged connections for pipe over 2” diameter; threaded connections acceptable for 2” diameter or less.
      f. All wetted parts shall be brass or stainless steel.
      g. No moving parts
   2. Signal Converter/Transmitter
      a. Provide four-wire, externally powered transmitter with non-interactive zero and span adjustments.
      b. Hardwired I/O (if required): Flow signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow).
   3. Performance:
      a. ±1% of reading over 25:1 turndown
      b. ±2% of reading over 100:1 turndown
      c. Minimum measurable flow: 500:1 turndown
      d. Repeatability: ≤ ± 0.2%
      e. NIST traceable factory calibration performed on accredited water flow test rig.
   4. Manufacturers (order of preference)
      a. Onicon F-4600
      b. No known equal

E. The following types of flow meter are not acceptable for high-accuracy applications:
   1. Turbine meters
   2. Clamp-on ultrasonic
2.7 THERMAL ENERGY (BTU) METERS FOR WATER

A. General
   1. Provide flowmeter, temperature sensors and communications/control unit sold and warranted as a package from a single manufacturer.
   2. Accuracy: ±1% factory calibrated, traceable to NIST with certification.
   3. BTU meter shall be UL listed as a complete package.

B. Sensors
   1. Temperature sensors shall be matched RTD or solid state temperature sensors with a differential temperature accuracy of ±0.15°F.
   2. Flow meter may be any high accuracy flow meter type listed in Article 2.6.

C. Communications
   1. Signal converter unit shall provide at least the following data to the DDC System:
     a. Supply temperature
     b. Return temperature
     c. Flow rate
     d. Energy rate (BTU/hr)
   2. All I/O connections shall be to signal converter. Do not connect sensors or meters directly to DDC System.
   3. All I/O points shown as hardwired on Contract Drawing control schematics must be hardwired.
   4. Points shown as networked may be transmitted as BACnet objects via network, or as hardwired I/O points.

D. Manufacturers (order of preference)
   1. Onicon System 10
   2. Onicon System 40 (if hardwired I/O is sufficient for required application; see Contract Drawing control schematics)
   3. Onicon System 30 utilizes turbine meters and is not acceptable
   4. No known equal

2.8 DAMPERS

A. Refer to Division 23.

2.9 AIR TEMPERATURE SENSORS

A. General
   1. Thermistor or RTD type sensor, suitable for temperatures being sensed. Sensor full scale shall not be less than 125% of expected range, as indicated on Contract Drawing control schematics or in sequences of operations (Section 259000).
   2. Accuracy as required to satisfy Paragraph 2.1F and Section 25 50 00.
      a. Inaccuracy due to wire resistance shall in no case exceed 0.5°F. Select wire gauge and/or provide transmitter if necessary to meet this requirement.
   3. Drift shall not exceed 0.3°F per year.
   4. Sensor shall not require recalibration for at least five years
5. Temperature Transmitter
   a. Provide when required for compatibility with controller or to meet specified accuracy.
   b. Output: 4-20mA linearly across specified temperature range
   c. Include non-interactive zero and span adjustments
   d. Accuracy: ±0.1°F across sensor range

B. Duct Temperature Sensor, Single-Point Insertion
   1. Use in ducts not affected by temperature stratification.
   2. Probe shall be stainless steel.
   3. Provide with junction box for wiring connections and gasket to prevent air leakage and vibration noise.
   4. Minimum insertion length of 20% of duct width

C. Duct Temperature Sensor, Averaging
   1. Averaging sensors shall be used in the following locations and situations:
      a. When shown on Contract Drawing control schematics
      b. Air handler mixing plenums
      c. Ductwork of 25 ft² or larger cross-sectional area, or more than 6 ft in height or width.
      d. Any ducts affected by temperature stratification
   2. Sensor length shall be at least 1 linear foot for each 2 ft² of duct area.
   3. Provide sensor length as required to meet installation requirements (see Paragraph 3.4B.3). Provide multiple sensors if required.
   4. Probe shall be flexible aluminum or copper.
   5. Provide with junction box for wiring connections and gasket to prevent air leakage and vibration noise.

D. Outdoor Air Temperature Sensor
   1. Encapsulated or wall-mount temperature sensor installed in aspirated enclosure as specified in Article 2.17.

E. Manufacturers (alphabetical order)
   1. Automated Logic Corp
   2. Building Automation Products Inc
   3. Kele Associates
   4. Mamac
   5. Or equal

2.10 ROOM TEMPERATURE SENSORS

A. Room Temperature Sensor, Air
   1. Provide wall mounted, low-profile DDC temperature sensor only – no display or occupant controls. (For thermostats, see Article 2.11.)
   2. Plate-Type
      a. Flush-mount stainless steel plate with sensor permanently bonded to back side of plate
      b. Kele KTP series or equal
   3. Button-Type
      a. Flush-mount button, max 1" diameter x 1/8" thick
b. Secure to wall with adhesive backing or threaded connection

c. BAPI LP, Titan Products TPWBS, or equal

4. Color selected or painted to match wall

2.11 THERMOSTATS, DIRECT DIGITAL

A. General

1. Thermostat shall consist of a sensing element within a ventilated cover.
2. Cover shall be aesthetically pleasing and designed for wall box mounting in occupied space.
3. Provide with insulated base and wall box.
4. For thermostats connected to terminal box controller that requires calibration, include port for connection of POT or laptop.

B. Communication

1. Contract Drawing control schematics may show hardwired point connections but thermostat may connect to BAS via any of the following methods:
   a. Hardwired points (4-20 mA or 0-10 V)
   b. As a BACnet networked device, on a Secondary Control LAN.
   c. Connected directly to terminal unit controller, where controller provides thermostat data as BACnet objects to BAS. A proprietary connection between thermostat and controller is acceptable if and only if all thermostat data is available as BACnet objects from the terminal unit controller.

2. Thermostat may use wireless communication with the following restrictions
   a. Each thermostat shall communicate directly with the device that it controls, without intermediate device. Mesh-network communication is not acceptable without approval from Engineer of Record.
      1) Deviations from this requirement will be considered with appropriate submittals. See Wireless Networking requirements in Section 25 50 00. If deviation is sought, provide pre-submittal with complete information on proposed device. Wireless devices submitted for the first time with Submittal Package 1 will be rejected.
   b. DDC Contractor assumes full responsibility for the reliable and robust performance of wireless communication. If wireless connection is deemed unreliable by Engineer of Record, Commissioning Authority, or Owner, DDC Contractor shall be responsible for replacing wireless thermostats with wired equivalents at no cost to the Owner.

C. Thermostat Types

1. Type 1 – No Display, No Controls
   a. Blank cover
   b. No occupant controls

2. Type 2 – With Display, No Controls
   a. Cover shall include integral LCD display showing current temperature and active setpoint.
   b. No occupant controls.
3. Type 3 – With Display, With Controls
   a. Display per Type 2 thermostat.
   b. Include means for occupant to adjust setpoint (buttons, dials, or sliders).
      1) Heating and cooling setpoint shall be independently adjustable.
      2) Setpoint adjustment shall be capable of being limited by BAS in software. If
         setpoint limitation function resides in thermostat, limits must be adjustable
         though BAS interface. Devices which require setpoint limitations to be
         programmed at the thermostat are not acceptable.
   c. Include override pushbutton (“janitor’s button”) capable of being programmed to start
      system outside of scheduled occupancy.

4. Type of thermostat depends on the type of space in which it is installed. See
   Paragraph 3.4D.7.

D. Manufacturers (alphabetical order)
   1. Automated Logic Corp
   2. Building Automation Products Inc
   3. Kele Associates
   4. Mamac
   5. Or equal

2.12 AIR PRESSURE SENSORS

A. General
   1. Transmitter: Loop powered, two-wire 4-20 mA output with zero adjustment
   2. Repeatability shall be 0.3% or better.
   3. Select sensor based on expected range as shown on control drawings or as indicated in
      sequences of operations (Section 259000).
         a. For unidirectional sensors, the maximum of expected range (i.e. largest positive or
            negative reading) shall be no more than 75% of sensor full scale.
         b. For bidirectional sensors, expected range shall be between 25% and 75% of sensor
            full scale.
   4. Provide with static pressure pickup tip/port with flexible tubing. Select based on
      application, as follows:
         a. Duct or filter pressure: Pitot tip, Dwyer A-302 or equal
         b. Plenum pressure: Straight tip with surge damper, Dwyer A-421 or equal
         c. Space pressure: Flush-mount wall plate with screened port, Dwyer A-417 or A-465,
            or equal
         d. Outdoor pressure: Outdoor pickup port shielded to minimize effects of wind gusts,
            Dwyer A-306 or A-420, or equal
   5. Provide with plastic housing suitable for surface mounting.

B. Differential Sensor, General Applications
   1. Sensor: Differential capacitance cell, with temperature compensation
   2. This type of sensor may be used for any application with pressures over ±0.5 inches
      where a fixed-range sensor is not required per this Article (see below) or indicated on
      Contract Drawing control schematics.
   3. Sensor range may be switch-selectable. Set sensor range per Paragraph 2.12A.3.
   4. Accuracy shall be no less than ±1% of full scale selected for application (not ±1% of
      sensor maximum range).
5. Provide with LCD display when installed at air handling unit or in mechanical room or other readily accessible location. Display is not required for sensors located above ceiling or under raised floor.

C. Differential Sensor, Fixed Range for Low Pressure/High Precision Applications
   1. Sensor: Differential capacitance cell, with temperature compensation
   2. Provide fixed-range sensor for any of the following applications:
      a. All pressures less than ±0.5 inches
      b. Building pressure monitoring or control
      c. Underfloor air distribution plenum pressure
      d. Differential pressure across outdoor air intake
   3. Provide fixed-range sensor. Switch-selectable range is not acceptable for this application. Select sensor range per Paragraph 2.12A.3.
   4. Accuracy shall be no less than ±0.25% of full scale.
   5. Provide with LCD display when installed in mechanical room or other readily accessible location. Display is not required for sensors located above ceiling or under raised floor.

D. Terminal Unit Velocity Pressure Sensor
   1. Sensor: Hot-wire flow-based differential pressure sensor. Diaphragm-style sensor does not provide sufficient accuracy and is not acceptable.
   2. Combination of pressure transducer and associated controller shall be capable of stable control to a setpoint of 0.004 inches or lower differential pressure.
      a. Overall accuracy (including impact of A/D conversion) shall be no worse than ±0.002 inches differential pressure.
      b. Overall resolution (including impact of A/D conversion) shall be no worse than ±0.001 inches differential pressure.
   3. Calibration software shall use a minimum of two field measured points, minimum and maximum airflow, with curve fitting airflow interpolation in between.
   4. Sensor may be integral to terminal unit controller, or separate but mounted with controller.

E. Manufacturers (alphabetical order)
   1. Air Monitor
   2. Dwyer
   3. Modus
   4. Paragon
   5. Setra
   6. Or equal

2.13 AIRFLOW MEASUREMENT STATIONS

A. VAV Terminal Unit Airflow Measurement
   1. Unless otherwise noted on VAV schedule, terminal unit airflow measurement is by terminal unit manufacturer’s differential pressure pickup in combination with a velocity pressure sensor meeting the requirements of Paragraph 2.12D.

B. Thermal Dispersion Type
   1. AFMS shall consist of one or more thermal mass flow sensors and associated controller/transducer.
2. Airflow probe shall span the entire area of the duct or fan inlet in which the AFMS is mounted, with sensor array density based on application per manufacturer’s requirements.

3. Materials:
   a. Sensor: Hermetically sealed bead-in-glass thermistor
   b. Probe: Stainless steel
   c. Brackets: Stainless steel

4. Operating limits
   a. Transmitter:
      1) Humidity: 5% to 100% non-condensing
      2) Temperature: -20°F to +160°F
   b. Sensor/Probe:
      1) Humidity: 0% to 95%
      2) Temperature: -20°F to +120°F

5. Airflow measurement accuracy: Installed total accuracy shall be better than ±3% of reading for ducted installations, and better than ±5% of reading for non-ducted (outdoor air intake) applications.
   a. Minimum accurately-measured air velocity shall be no less than 50 FPM.
   b. Maximum accurately-measured air velocity shall be as required by application.
   c. Installed accuracy shall include the probe itself plus the electronics for converting probe signal to an electronic signal proportional to airflow.

6. Temperature accuracy shall be ±0.15°F.

7. Airflow and temperature sensors shall be calibrated to NIST-traceable standards for airflow/velocity.

8. Pressure drop: Unrecovered pressure drop shall not exceed 0.025 inches at 2000 FPM.

9. Communication: Controller/transducer shall provide hardwired (4-20 mA and/or 0-10 VDC) outputs and/or BACnet network outputs as required by application for all points indicated. Refer to Contract Drawing control schematics
   a. If AFMS is used for control of devices (refer to sequences of operations) BAS input points must be hardwired. Networked points are for monitoring only and are not acceptable for direct control applications.

10. Sensor Grid Density
    a. Sensor grid shall be per manufacturer published recommendation as required to achieve specified accuracy.
    b. Sensor nodes shall be distributed uniformly across the duct/plenum to obtain accurate measurement of average flow velocity.

11. Required Submittals: For each separate AFMS unit, provide the following:
    a. Sensor grid density and arrangement/configuration (e.g. 2 x 3, 4 x 3).
    b. Calculation of air velocity at scheduled minimum airflow.
    c. Calculation of air velocity at scheduled maximum airflow.
    d. Documentation that both the minimum and maximum air velocities are within the specified operating range of the selected airflow measurement station.

12. Manufacturers:
    a. For air handling units, outdoor air intakes, and ducts over 2 ft²:
       1) Ebtron Gold Series (GTX116-P)
       2) Or equal
b. For square ducts between 1 ft$^2$ and 2 ft$^2$:
   1) Ebtron Hybrid Series (HTX104-P), or Gold Series if both hardwired and
      networked I/O is required
   2) Or equal

c. For round ducts 4" to 14" diameter:
   1) Ebtron EF-X series
   2) Or equal
d. For fan inlets:
   1) Ebtron GTX108-F
   2) Or equal

C. Vortex-shedding Type

1. AFMS shall consist of one or more airflow sensors and associated controller/transducer.
2. Airflow probe shall span the entire area of the duct or fan inlet in which the AFMS is
   mounted, with sensor array density based on application per manufacturer's
   requirements.
3. Materials:
   a. Sensor Base & Shroud: Anodized Aluminum
   b. Shedder: ABS plastic
   c. Brackets: Galvanized steel
4. Operating limits
   a. Transmitter:
      1) Humidity: 0% to 90% non-condensing
      2) Temperature: -20ºF to +150ºF
   b. Sensor/Probe:
      1) Humidity: Non-condensing
      2) Temperature: -20ºF to +120ºF
5. Airflow measurement accuracy: Installed total accuracy shall be better than ±5% of
   reading for ducted installations.
   a. Minimum accurately-measured air velocity shall be no less than 50 FPM.
   b. Maximum accurately-measured air velocity shall be as required by application.
   c. Installed accuracy shall include the probe itself plus the electronics for converting
      probe signal to an electronic signal proportional to airflow.
6. Pressure drop: Unrecovered pressure drop shall not exceed 0.025 inches at 2000 FPM.
7. Communication: Controller/transducer shall provide hardwired (4-20 mA and/or
   0-10 VDC) outputs and/or BACnet network outputs as required by application for all
   points indicated. Refer to Contract Drawing control schematics.
   a. If AFMS is used for control of devices (refer to sequences of operations) BAS input
      points must be hardwired. Networked points are for monitoring only and are not
      acceptable for direct control applications.
8. Sensor Grid Density
   a. Sensor grid shall be per manufacturer published recommendation as required to
      achieve specified accuracy.
   b. Sensor nodes shall be distributed uniformly across the duct/plenum to obtain
      accurate measurement of average flow velocity.
9. Required Submittals: For each separate AFMS unit, provide the following:
   a. Sensor grid density and arrangement/configuration (e.g. 2 x 3, 4 x 3).
   b. Calculation of air velocity at scheduled minimum airflow.
   c. Calculation of air velocity at scheduled maximum airflow.
   d. Documentation that both the minimum and maximum air velocities are within the specified operating range of the selected airflow measurement station.

10. Manufacturers:
    a. For Lab Exhaust:
        1) Accutrol VTF
        2) Or equal

2.14 CARBON DIOXIDE SENSORS

A. General
   1. CO2 sensors are delicate optical instruments. Protect from shock. Store in manufacturer’s packaging until ready for installation. Recalibration may be required after rough handling.
   2. Detachable base with all field wiring termination on base.
   3. Provide wall-mounted sensors with display; duct-mounted sensors do not require display.
   4. Provide duct-mounted sensors with aspirating probe.
   5. Wall-mounted sensors may be combined/integrated with thermostat.
   6. Factory calibrated and set to 0-2000 PPM range
   7. Drift shall not exceed 2%.
   8. Response time shall be 1 minute or less.
   9. Sensor shall not require recalibration for a minimum of 5 years, guaranteed.
   10. If sensor is found to be out of calibration, DDC Contractor shall recalibrate or replace at no additional cost to the Owner within 5 years of purchase date.
   11. Rated ambient conditions:
       a. Air temperature: 32°F - 120°F
       b. Relative humidity: 0% - 95% non-condensing
   12. Include elevation adjustment
   13. Signal output: 4-20 mA or 0-10 V, or as BACnet networked device on secondary control LAN.

B. Dual Channel Self-Calibrating Sensor (Type 2)
   1. Non-dispersive infrared sensor utilizing single-beam, dual-wavelength technology with a single receiver. Dual-beam single-wavelength sensors, single beam sensors, and sensors with dual receivers are not acceptable.
   2. Accuracy: larger of ±40 PPM or ±3% of reading from 0 to 2,000 PPM at temperatures from 60°F to 90°F
   3. Sensor shall compensate for the aging of the infrared source utilizing a non-adsorbing wavelength to provide a reference for automatic recalibration. Reference and measurement channels shall both utilize the same light source and the same receiver.
   4. Manufacturers (order of preference)
       a. Vaisala GMW80 series (wall-mount) or GM20 series (duct mount)
       b. Dwyer CDT series (not CDD or CDW)
       c. No known equal
2.15 HUMIDITY SENSORS

A. General

1. Sensor shall be thin film capacitance type.
2. Sensor element shall be field-replaceable without requiring recalibration.
3. Shall include 2-wire transmitter producing a continuous 4-20 mA signal proportional to relative humidity (%RH) or output as required (see Paragraph 2.15A.12).
4. Temperature range: 32°F to 122°F
5. Humidity range: 0% to 100% RH
6. Sensor shall be factory-calibrated and NIST traceable.
7. Resolution: 0.1% RH
8. Repeatability: 0.5% RH at RH < 90%
9. Temperature Effect: Less than 0.06% per ºF at baseline of 70°F.
10. Response time at 70°F in still air: Less than 20 seconds
11. Provide sensor with cover suitable for wall (indoor space), duct or outdoor installation as required by application.
   a. For wall mounting: Aesthetically pleasing ventilated cover, designed for wall box mounting in occupied space, with insulated base.
   b. For duct mounting: Junction box for wiring connections and gasket to prevent air leakage and vibration noise. Sensor probe shall extend into duct at least 20% of duct width.
   c. For outdoor installation, provide one of the following:
      1) Provide outdoor humidity sensor with integrated flow-through radiation/rain shield. Sensors equipped with this kind of radiation shield (i.e. not fan aspirated) shall not be used for outdoor temperature measurement. For outdoor temperature, provide temperature sensor in aspirated enclosure per Paragraph 2.9D.
      2) Provide wall-mounted sensor in aspirated sensor enclosure satisfying Article 2.17. Combined measurement of outdoor temperature and humidity is acceptable when using an aspirated enclosure.
12. Sensor shall output relative humidity (%), dewpoint temperature, or wetbulb temperature as indicated on control drawings or as required by the application.
   a. Contractor shall select the model/options to provide required output, or shall configure sensor to provide required outputs, as appropriate to the sensor being used.
   b. Calculated outputs (dewpoint temperature, wetbulb temperature) for outdoor installation shall require an aspirated enclosure per Paragraph 2.15A.11.c.2.) (This ensures accurate measurement of drybulb temperature, which is required for accurate calculation of the dewpoint or wetbulb temperatures.)

B. Standard Accuracy (3%)

1. Accuracy at 70°F: no worse than ±3% over 0% - 90% RH; ±5% over 90% - 100% RH
2. Drift: no more than 1% per year
3. Manufacturers (order of preference)
   a. Viasala HMW82 (wall), HMD82 (duct), HMS82 (outdoor)
   b. Rotronic HF320-D (duct), HF320-S (wall mount, indoor occupied space), HF320-W (wall mount, indoor mechanical or hidden space)
   c. No known equal

C. High Accuracy (2%)

1. Accuracy at 70°F: no worse than ±2% over 0% - 90% RH; ±3% over 90% - 100% RH
2. Drift: no more than 0.5% per year
3. Manufacturers (order of preference)
   a. Viasala HMW92 series (wall), HMD60 series (duct), HMS112 (outdoor)
   b. Rotronic HF320-D (duct), HF320-S (wall mount, indoor occupied space), HF320-W (wall mount, indoor mechanical or hidden space)
   c. No known equal

D. Ultra High Accuracy (1%)
   1. Accuracy at 70°F: no worse than ±1% over 0% - 90% RH; ±2% over 90% - 100% RH
   2. Drift: no more than 0.5% per year
   3. Manufacturer warranty no less than 10 years
   4. Manufacturers (order of preference)
      a. Viasala HMT331 (wall) or HMT333 (duct)
      b. No known equal

2.16 SWITCHES AND STATUS INDICATORS

A. Flow Switch
   1. Thermal Type
      a. Calorimetric flow switch resistant to fouling and corrosion, suitable for liquid or gas.
      b. Shall not require more than the larger of one pipe diameter or 12 inches of straight piping for proper operation
      c. Adjustable switch point
      d. IFM or equal

B. Differential Pressure Switch
   1. Diaphragm with adjustable setpoint and adjustable differential.
   2. Snap-acting Form C contacts rated for the application.
   3. Automatic reset.
   4. For water, switch must tolerate differential pressure up to 60 PSI.
   5. For air, provide with manufacturer's recommended static pressure sensing tips.

C. Current Switch
   1. Solid-core or split-core
   2. Range as required by application
   3. Adjustable trip point
   4. Switch:
      a. Solid state
      b. Normally open
      c. Relay output: minimum 120 VAC or VDC, 0.3 Amps.
      d. Zero off state leakage
   5. Low Frequency Limit: 6 Hz
   6. LED trip indicator
   7. UL and CSA approved
   8. May be used to start other devices if so indicated on Contract Drawing control schematics.
9. Manufacturers (alphabetical order)
   a. Senva C-1220/1320/2220/2320
   b. Veris Industries H-308/608/708/808/908
   c. RE Technologies CS1150A/SCS1150A
   d. Or equal

D. Leak Detector, Spot
   1. Gold plated sensing probes or remote sensing pads, as required by application.
   2. Encapsulated in epoxy or polymer – no exposed metals other than probes.
   3. Adjustable, weather-proof stand.
   4. Automatically resets when conductive fluid is no longer present.
   5. Relay contact outputs rated at 1amp at 24 VAC or VDC. Relay contact quantity as required by application or indicated by Contract Drawing control schematics.
   6. Normally energized relay, will alarm when power is lost.
   7. LED power and alarm indicators [and audible alarm].
   8. Powered with 12-24 VAC or VDC from BAS panel.
      a. Battery power not acceptable.

9. Manufacturers (alphabetical order)
   a. DIT DD1
   b. Dwyer WD3-LP
   c. Kele WD-1x
   d. Veris MX1V
   e. Or equal

10. Not to be confused with Condensation Detector.

E. Leak Detector, Area
   1. Non-conductive, hydrophobic, polymer tape or cable
   2. Select cable/tape length as required to fully protect area indicated on Contract Drawings, per manufacturer instructions.
   3. Weather resistant sensor module.
   4. Automatically resets when conductive fluid is no longer present.
   5. Relay contact outputs rated at 1amp at 24 VAC or VDC. Relay contact quantity as required by application or indicated by Contract Drawing control schematics.
   6. Normally energized relay, will alarm when power is lost.
   7. LED power and alarm indicators [and audible alarm].
   8. Powered with 12-24 VAC or VDC from BAS panel.
      a. Battery power not acceptable.

9. Manufacturers (alphabetical order)
   a. DIT AT1-M2
   b. Dwyer WD
   c. Kele WD-2-T
   d. Veris LD310
   e. Or equal

10. Not to be confused with Condensation Detector.

F. Condensation Detector
   1. Condensation detector shall sense the presence of liquid water or water film on the surface to which it is mounted. A humidistat or detector which measures dewpoint or relative humidity is not acceptable.
2. Detector shall provide a binary input signal to BAS upon condensation detection, or upon detector failure.

3. Manufacturers:
   a. Consense (www.consense.com)
      1) CG-ICM-F for mounting to flat surfaces
      2) CG-ICM-P for mounting to pipes
   b. No Known Equal for HVAC applications. All other “condensation” detectors on the market actually measure humidity, or are intended for microelectronics applications.

4. Not to be confused with Liquid Water Detector.

G. Low Temperature Detector (freeze-stat)

1. Capable of detecting temperature drop in any one foot length of sensor. Install across entire face of coil or element being protected.

2. Rated ambient conditions:
   a. Air temperature: 0°F - 144°F
   b. Relative humidity: 5% - 95% non-condensing

3. Battery power not acceptable

4. Setpoint range: 15°F - 55°F. Set to 38°F unless otherwise indicated on plans or sequences.

5. DPST contacts: Main contacts and auxiliary contacts respond simultaneously on detection of temperature drop.


7. Junction box for wiring connections with gasket to prevent air leakage and vibration noise.

8. Manufacturers: (alphabetical order)
   a. Honeywell
   b. Johnson
   c. Siemens
   d. Or equal

2.17 ASPIRATED OUTDOOR SENSOR ENCLOSURES

A. General

1. Designed for installation in exposed outdoor locations.

2. Provide fan-aspirated radiation shield that combines both active and passive aspiration to minimize the effects of radiation.
   a. Motor-driven fan draws air through the sensor chamber and exhausts it through the top of the shield.
   b. Triple-walled sensor chamber shielded by flow-through plates.

3. Electronics mounted in watertight gasketed enclosure.

4. A single enclosure may be used for more than one instrument/sensor if designed and intended by the manufacturer to house multiple devices.

B. Manufacturers (order of preference)

1. Kele A21
2. Davis Instruments 7747
3. Or equal

2.18 METER INTERFACE UNIT

A. General
1. The Meter Interface Unit (MIU) is a protocol translator that converts common types of utility meter signal encoding to Modbus, for connection to the BAS.
2. DDC Contractor shall provide MIU devices as required to connect BAS to site utility meters if such connections are indicated in Contract Drawings or Specifications.
3. The MIU shall be installed such that it does not interfere with the utility’s ability to read the meter, e.g. using a radio-read or touch-read interrogator. DDC Contractor shall provide a signal splitter if required to achieve this functionality.

B. Operating Conditions
1. Operating Temperature Range: 0°F-104°F
2. Power Input: 10-36 VDC, with integral overcurrent protection
3. Power Consumption: 3 watts maximum
4. MIU shall support wire diameters between 16AWG and 26AWG
5. MIU shall comply with UL60950-1 for safety and FCC Part 15, Class A for RF emissions
6. MIU shall be lead-free and ROHS compliant

C. Meter Input Ports
1. The MIU shall include at least two input ports capable of reading pulse-output meters, or encoder-output meters conforming with AWWA Standard C707-05.
2. The flow meter communication protocol(s) shall be recognized automatically by the MIU, without user-intervention. At a minimum, the MIU shall be compatible with the following protocols:
   a. Sensus Variable Length, 4 to 9 Digit.
   b. Sensus Fixed Length, 4 to 6 Digit.
   c. Neptune E-Coder Plus, 8 to 9 Digit.
   d. Neptune ProRead Basic, 3-6 Digit.
   e. K-Frame, 6 Digit.
   f. Mechanical Contact Pulse, 2000 Hz. Max.
   g. Solid-State Contact Pulse, 2000 Hz. Max.
   h. Open-Collector Pulse, 2000 Hz. Max.
3. The MIU shall automatically sample the flow meter(s) at pre-programmed intervals, and compute flow rate(s) based upon a delta-Volume/delta-Time finite difference calculation (fixed delta-Time or fixed delta-Volume).

D. Serial Ports
1. The MIU shall include at least one RS-232 or RS-485 serial port.
2. The MIU shall support data output through the serial port(s) using at least the following protocols:
   a. MODBUS/RTU
   b. MODBUS/ASCII
3. It shall also be possible to configure the MIU by connecting to the serial port(s) with a laptop computer.
4. The port shall be switchable between data output mode and configuration mode using a dip switch or similar.
E. Ethernet Port

1. The MIU shall include at least one Ethernet port, which supports data output using at least the following protocols:
   a. MODBUS/TCP
   b. MODBUS/UDP
   c. Allen Bradley ETHERNET/IP

2. The Ethernet port shall support both DHCP and static IP addressing.

3. The Ethernet port shall also provide the following services:
   a. Ping server
   b. Web server, providing meter rate and totalization, statistics, and auxiliary I/O data. Web server can be disabled in configuration.
   c. Telnet server, for remote configuration and management. Telnet server can be disabled in configuration. **When configuration is complete, telnet server shall be disabled for security reasons.**

4. The Ethernet port shall be pre-programmed with a unique, valid, IEEE-approved MAC address.

F. Manufacturers

1. SCADAmetrics Ethermeter EM-100
2. SCADAmetrics Touch-Read Filter TRF-x
3. SCADAmetrics Radio-Read Filter RRF-x
4. No Known Equal

2.19 TIME CLOCKS

A. General

1. Voltage and current rating suitable for service
2. Enclosure with hinged cover, with lockable hasp

B. Electromechanical Type

1. Seven-day switch timer with seven-day dial
2. Synchronous timing motor
3. Battery backup, minimum 8 hour endurance
4. Switch trippers capable of providing up to 8 signals per day
5. Outputs: 2 normally-open, 2 normally-closed

2.20 ELECTRIC CONTROL DEVICES

A. Push Button Switch

1. Momentary contact push button
2. NEMA ICS 2
3. Oil tight, type 800T
4. Quantity of N.O. or N.C. contacts as required
5. Contacts shall be snap-action type, and rated for minimum 120 VAC operation.

B. Selector Switch

1. Maintained contact
2. NEMA ICS 2
3. Oil tight, type 800T
4. Contact arrangement as required
5. Contacts shall be rated for minimum 120 VAC operation

PART 3 - INSTALLATION

3.1 GENERAL

A. All installation requirements in Division 23 and Section 25 50 00 shall apply to the Work done under this Section.

B. Subject to direction by the General Contractor, DDC Contractor shall perform Work in accordance with the general sequence of events outlined in Article 3.1 General of Section 25 50 00. If it is necessary to deviate substantially from this schedule, DDC Contractor shall notify Commissioning Authority and Engineer of Record.

C. DDC Contractor shall coordinate with other trades as required by Section 25 50 00. This shall include submitting documentation and coordination plans as described in that Section.

D. DDC Contractor shall protect all products and retain them in manufacturer packaging until installed, as required by Section 25 50 00.

E. DDC Contractor shall perform all Work under this Section in accordance with the manufacturer’s instructions and the general workmanship requirements specified in Section 25 50 00 and in Division 23. DDC Contractor shall in addition observe the following requirements:
   1. All sensors and products shall be mounted rigidly and adequately supported.
   2. Wires attached to sensors shall be sealed leak-tight in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.
   3. Sensors which provide data used to maintain a setpoint with variable-speed equipment (e.g. duct pressure sensor used for fan speed control, or end-of-loop differential pressure used for pump speed control) shall be hardwired directly to the same controller that controls the variable-speed equipment, which shall also be the controller where the variable speed control loop resides.

F. All products and devices shall be provided with enclosures, or installed in enclosures, as required by Section 25 50 00.

G. All power and control wiring shall be installed in accordance with Section 25 50 00, this Section, and other applicable codes and standards. All wiring and tubing shall be labelled and identified as specified in Section 25 50 00.

H. All products provided or installed under this Section shall be subject to testing, verification and commissioning as specified in Section 25 50 00. Provide Pre-Functional Test and Functional Test Reports as required by Section 25 50 00 for all products provided or installed under this Section.
3.2 ACTUATORS

A. Damper Actuators
   1. The actuator shall be direct coupled to shaft, without connecting linkage or jackshaft.
      a. Links or jackshafts are not acceptable unless specifically indicated in Contract Drawings.
      b. If installation requires linkages due to mechanical or space constraints, notify Engineer of Record in writing.
   2. For multiple-section dampers, provide one actuator for each section.
   3. Pre-compress dampers that have blade seals: Power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage; or follow manufacturer’s instructions to achieve same effect.
   4. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

B. Valve Actuators
   1. Install damper to valve shaft with a “keyed” connection to prevent rotational slippage.
      a. Use only manufacturer-approved coupling adapters, if one is required.
      b. Compression-clamping actuator to a round valve shaft is not acceptable.
   2. Install so that actuators, wiring and tubing connections are accessible for maintenance.
   3. If possible, install valve so that the position indicator is visible from floor or other readily accessible location. However, do not install valve with steam pointing below horizontal or down.

C. Normal Position and Fail-Safe
   1. For all actuators, normal position is the position with zero control signal.
   2. Fail-safe actuators shall assume normal position upon loss of power.
   3. Unless otherwise noted in Contract Drawing schedules or control schematics, install actuators with normal position as shown in the following table. Provide fail-safe actuators where required.

<table>
<thead>
<tr>
<th>Device</th>
<th>Normal Position</th>
<th>Fail-Safe Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU Outside Air Damper</td>
<td>CLOSED</td>
<td>Yes</td>
</tr>
<tr>
<td>AHU Return Air Damper</td>
<td>OPEN</td>
<td>Yes</td>
</tr>
<tr>
<td>AHU Exhaust/Relief Air Damper</td>
<td>CLOSED</td>
<td>Yes</td>
</tr>
<tr>
<td>VAV Box Dampers</td>
<td>OPEN</td>
<td></td>
</tr>
<tr>
<td>AHU Hot Water Coil Valve</td>
<td>OPEN</td>
<td></td>
</tr>
<tr>
<td>AHU Chilled Water Coil Valve</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>Fan-coil HHW and CHW Valve</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>CRAC CHW Valve</td>
<td>OPEN</td>
<td></td>
</tr>
<tr>
<td>Hot Water Reheat Coil Valve</td>
<td>CLOSED</td>
<td></td>
</tr>
<tr>
<td>Radiant Panel Control Valve (HHW or CHW)</td>
<td>CLOSED</td>
<td>Yes</td>
</tr>
<tr>
<td>Radiant Slab Control Valve (HHW or CHW)</td>
<td>CLOSED</td>
<td>Yes</td>
</tr>
<tr>
<td>Vivarium Hot Water Reheat Coil Valve</td>
<td>CLOSED</td>
<td>Yes</td>
</tr>
<tr>
<td>Water-to-Water Heat Exchanger</td>
<td>CLOSED</td>
<td>Yes</td>
</tr>
<tr>
<td>2-Position Valves for HHW/CHW Changeover</td>
<td>CLOSED</td>
<td>Yes</td>
</tr>
<tr>
<td>6-Way Valve for HHW/CHW changeover</td>
<td>CLOSED</td>
<td>Yes</td>
</tr>
<tr>
<td>Equipment Isolation Valve</td>
<td>OPEN</td>
<td></td>
</tr>
<tr>
<td>Bypass Valve</td>
<td>CLOSED</td>
<td></td>
</tr>
</tbody>
</table>
3.3 WATER SENSORS AND DEVICES

A. Temperature Sensors

1. All temperature sensors in pipes shall be installed in thermowell with thermally-conductive grease. Direct immersion installation is not acceptable.
2. Thermowell shall penetrate pipe by lesser of 8 inches or half pipe diameter. For small pipes, well shall be installed in an elbow into pipe length.
3. Insulate top of thermowell with a patch of closed-cell insulation, to provide a complete thermal break but allow easy access to sensor.
4. Install test port adjacent to each thermowell.
5. Provide sufficient wiring (or flexible conduit, per installation location) to allow sensor to be removed from thermowell for calibration or replacement.

B. Pressure Sensors

1. Install with manifold that provides for isolation and venting. Pressure sensors shall have 3-valve manifold; differential pressure sensors shall have 5-valve manifold.
2. Manifold shall permit removal of sensor without shutting down hydronic system.
3. Manifold vent ports shall be usable as test ports, or provide separate test ports adjacent to sensor.

C. Flow Meters

1. Install per manufacturer’s recommendations for unobstructed straight length of pipe both upstream and downstream of sensor. If sufficient straight pipe is not available, contact Engineer of Record for guidance.
2. Install with isolation valves immediately upstream and downstream of meter. If hot-tapping an operating hydronic system, provide hot-tap isolation valve instead to enable sensor removal without water supply system shutdown.
3. For Insertion-Type meters
   a. Install meter in correct orientation relative to pipe so that turbine is aligned with fluid flow.
   b. Install using manufacturer-provided depth gauge to ensure that sensor is correctly positioned at center of pipe. Always place depth gauge against exterior of pipe, not against pipe insulation.
4. Test meter per the manufacturer’s startup and commissioning recommendations.
5. Complete all manufacturer’s startup documentation and include with Pre-Functional Test report (see Submittals in Part 1 and Testing and Commissioning in Part 3 of Section 25500).

D. BTU Meters

1. Install flow sensor per Paragraph 3.3C.
2. Install temperature sensors per Paragraph 3.3A.
3. Connect to signal converter unit for I/O. All I/O points shown as hardwired on Contract Drawing control schematics shall be installed as hardwired points.

3.4 AIR SENSORS AND DEVICES

A. Control dampers shall be installed per the requirements of Division 23.
B. Duct Temperature Sensors

1. If installing sensor near a coil:
   a. Upstream of coil, install a minimum of 6 inches from coil.
   b. Downstream of coil, install a minimum of 12 inches from coil if possible, 6 inches absolute minimum.
   c. No part of the sensor or its support elements or conduit shall be in contact with the coil, coil framing or coil support elements.

2. Single Point Duct Sensors
   a. Install probe at approximate midpoint of duct height.
   b. Install such that probe penetrates minimum 20% of duct width, to avoid boundary layer.

3. Averaging Duct Sensors
   a. Install sensor in serpentine manner with a minimum of four vertical passes ("M" pattern), covering full width and height of duct.
   b. The entire length of the sensor must be installed fully inside duct.
   c. Support at each bend with capillary clip.
   d. Where located in front of filers (e.g. mixed air temperature sensor), maintain access for filter removal.

C. Outdoor Air Sensors

1. Install sensor in aspirating enclosure. See Article 2.17.
2. Installation location shown on Contract Drawings is approximate.
3. DDC Contractor is responsible for selecting actual installation location to provide accurate readings without distortion from solar or building influences.
   a. Good locations are shielded from the sun and away from reflective surfaces, air intakes and exhausts, and heat producing equipment.
   b. Poor locations include above sun-exposed walls, near windows, doors and exhaust vents, under eaves, or near equipment.
   c. If no good location is available, notify Engineer of Record.

D. Room Sensors and Thermostats

1. Room sensors and thermostats shall be installed on concealed junction boxes properly supported by wall framing. Exception: Button-type sensors may be installed directly to wall without box if permitted by local code and AHJ.
2. Install all devices with insulated base.
3. For sensors mounted in exterior walls, seal all junction box openings with mastic sealant and pack junction box with fiberglass insulation.
4. For sensors on exposed unfurred columns, use Wiremold or equal raceway that is smallest required to enclose wiring and Wiremold or equal junction boxes that are narrowest required to enclose sensor and wiring connections. Color shall be per the architect; submit for approval prior to installation.
5. Install sensors in locations as shown on Contract Drawing mechanical floorplans. If installation in indicated location is not feasible, notify the Engineer of Record.
6. Unless otherwise noted on Contract Drawings, wall-mounted sensors shall be installed at same centerline elevation as adjacent electrical switches, 4 feet above the finished floor where there are no adjacent electrical switches, and within ADA limitations.
   a. Wall mounted CO2 sensors shall in all cases be installed between three and six feet above finished floor, to comply with code requirements.
7. Unless otherwise called out on Contract Drawing mechanical floorplans or zone schedule, install thermostat Types based on location:
   a. Open offices: Type 2  
   b. Private offices: Type 3  
   c. Corridors/hallways: Type 1  
   d. Conference/meeting rooms: Type 3  
   e. Classrooms, labs, multi-purpose rooms: Type 3  
   f. Lobbies, public spaces: Type 2  
   g. Equipment rooms and other back-of-house spaces: Type 2  
   h. Others not listed: Request clarification from Engineer of Record

E. Differential Pressure Sensors

1. Pressure transducers shall be installed in control enclosures. Do not install on monitored equipment, ductwork or other location subject to vibration.
   a. Exception: Terminal unit transducers may be installed on terminal unit.
   b. Exception: Filter differential pressure transducers shall be mounted on outside of filter housing or filter plenum with display clearly visible (replaces Magnehelic).

2. Connect with tubing as specified in Section 25 50 00. Label tubing as required by Section 25 50 00.

3. Terminate tubing at static pressure probe or port selected based on application. See Paragraph 2.12A.42.12A.3. Probes shall be securely fastened. Pitot tips shall point into directly airflow.

4. Install both high-pressure and low-pressure tubing with capped tee fittings near pressure transducer, for use as test ports.

5. Identify and label all pressure transducers. See Identification in Section 25 50 00.

6. Duct static pressure sensors shall be installed as follows:
   a. Connect low-pressure (reference) port to building pressure sensor high-pressure tubing with tee fitting. If there is no building pressure sensor, terminate low pressure tubing in appropriate location for building ambient pressure measurement, per Paragraph 3.4E.7.b.
   b. Connect high-pressure port to duct pressure probe.
   c. Install probe in location as shown on Contract Drawing mechanical plans. If installation location is unclear or not feasible, contact Engineer of Record for clarification.

7. Building static pressure sensors shall be installed as follows:
   a. Connect low-pressure (outdoor ambient) port to outdoor pressure probe located outside at high point of building, sheltered from wind.
   b. Connect high-pressure (building ambient) port to wall-plate pressure port appropriately located to provide consistent and accurate building pressure signal. Do not locate near elevators, exterior doors, atria, or HVAC diffusers.

8. Underfloor plenum pressure sensors shall be installed as follows:
   a. Connect low-pressure (reference) port to wall-plate pressure port located adjacent to zone thermostat. Tubing may alternatively terminate inside thermostat, if cover has openings to allow free air flow.
   b. Leave high pressure port open to plenum.
   c. Install pressure transmitter in underfloor plenum below low-pressure port location. Do not locate near plenum supply outlet.

F. Airflow Measurement Stations

1. Install AFMS as shown on Contract Drawing mechanical plans.
2. Install AFMS in accordance with manufacturer requirements, maintaining minimum straight duct run to ensure accuracy.

3. If installation location shown on plans is does not meet manufacturer requirements for minimum straight duct run, or if an alternative location would provide equal function and better accuracy, DDC Contractor shall request clarification from Engineer of Record.

3.5 SWITCHES AND STATUS INDICATORS

A. Current Switch
   1. Adjust current setpoint (i.e. ON/OFF signal threshold) as follows:
      a. For fan status, with discharge damper: Adjust so that fan status is OFF when fan discharge damper is fully closed while fan is running.
      b. For fan status, with belt-driven fan: Adjust so that fan status is OFF when fan belt is broken and motor is running.
      c. For pump status: Adjust so that pump status is OFF when pump is running with shutoff valves closed (i.e. pump is dead-headed).

B. Leak Detectors, Spot or Area
   1. Install to flat surface (bottom of drain pan, floor, etc) unless otherwise indicated on Contract Drawing control schematics.
   2. Set detector to react to 1/16” depth of water accumulation, maximum, unless otherwise indicated on Contract Drawing control schematics.
   3. Secure detector per manufacturer instructions.
   4. Do not use liquid water detector for applications where a condensation detector is indicated.

C. Condensation Detector
   1. For pipe installation (Consense model CG-ICM-P)
      a. Install detector to bare metal pipe, downstream of control valve, as close as feasible to radiant panel/chilled beam.
      b. Remove insulation for 2” around detector, to allow free circulation of air to detector. Clean pipe surface.
      c. Ensure that provided thermally conductive pad is between detector and pipe, and is in contact with bare metal of pipe. If conductive pad is missing, obtain replacement from manufacturer before installing detector. Do not install detector without thermal pad.
      d. Firmly secure detector to pipe using nylon zipties, as shown in manufacturer literature.
   2. For flat surface installation (Consense model CG-ICM-F)
      a. Install detector flat to back side of chilled beam/radiant panel, or to interior bottom surface of drip pan, as indicated on control drawings.
      b. Remove insulation from mounting surface. Clean surface with alcohol for good adhesion.
      c. Adhere detector with provided 2-way thermal tape. If tape is missing, obtain replacement from manufacturer before installing detector. Do not install detector without thermal tape; regular 2-way tape is not acceptable.
3. Detector may be damaged by dust, water or VOCs. It is recommended that the detector be installed only after other construction activities are complete.

4. Do not use condensation detector for applications where a liquid water detector is indicated.

D. Low Temperature Detector (freeze-stat)

1. Install with junction box for wiring connections.
2. Install with gasket to prevent air leakage and vibration noise.
3. Hardwire primary output to VFD emergency stop. Wire auxiliary output to BAS to indicate freeze-stat activation.

END OF SECTION
SECTION 255000 - BUILDING AUTOMATION HARDWARE AND NETWORKING

PART 1 - GENERAL

1.1 SUMMARY

A. The DDC Contractor shall furnish and install a complete Direct Digital Control Building Automation System in accordance with Contract Drawings, this Section, and other Division 25 Sections issued with this Specification.

B. DDC System shall consist of an internetwork of ANSI/ASHRAE 135 native BACnet DDC devices, interfaces and software, as well as sensors, actuators, control devices, enclosures, interconnecting conduit and wiring.

C. DDC System shall monitor and/or control the following systems in accordance with Contract Drawing control schematics and Section 25 90 00 “Building Automation Sequences of Operations”
   1. HVAC Systems
   2. Plumbing Systems
   3. Lighting Control Systems
   4. Power Meters or Power Monitoring Systems

D. Coordinate with other trades as required to fulfill requirements of Contract Drawings and this Section.
   1. Furnish selected control devices to equipment and systems manufacturers for factory installation and to contractors of other trades for field installation under other Sections and Divisions. Supervise and coordinate the installation of components furnished under this Section but installed under other Divisions of the Specification. See Paragraphs 3.4C and 3.4D.
   2. Coordinate with equipment manufacturers and contractors of other trades all installation, connection, and interface details required to integrate products by others (including but not limited to VFDs, gateways, and package unit controllers) to the DDC System. See Paragraph 3.4E.
   3. Test and Balance: Coordinate with TAB Contractor to determine setpoints and other parameters required to program Sequences of Operations per Paragraph 3.4F. Assist TAB Contractor in balancing tasks which require DDC System interaction per Paragraph 3.16D.
   4. Life Safety: The DDC System is not a life-safety system. Smoke alarm and smoke control system are by others. DDC Contractor shall provide hardwire interlock connections to the smoke/fire system, and shall connect to smoke detectors, smoke/fire alarm systems, and/or smoke control dampers for monitoring purposes only, as shown in Contract Drawing control schematics. See Paragraph 3.4F.5.
   5. Lighting Control: Lighting control system is provided by Division 26 and is separate and distinct from DDC System. DDC Contractor shall map sensor outputs from and control inputs to the lighting control system. See Paragraphs 3.4H and 3.7G.5.
   6. Meters: Connect DDC System to water, gas, and/or power meters for monitoring. Meters are installed by their respective Division. See Paragraph 3.4I.
   7. Commissioning: Perform commissioning activities and assist Commissioning Authority and/or Commissioning Coordinator in the execution of commissioning tasks per Article 3.16.

E. DDC Contractor shall read and respond to all parts of this Section.
1. To facilitate the Work under this Section, a searchable digital version of this document will be provided to the DDC Contractor upon request to the Engineer of Record.
   a. Searchable digital version includes live hyperlinked cross-references, such that clicking “see Paragraph XX” will jump to Paragraph XX.
   b. Searchable digital version is formatted with PDF “bookmarks” corresponding to the outline levels of the document, as an aid to navigation.
   c. DDC Contractor is strongly encouraged to request this digital version if it is not provided through standard channels.

2. It is understood that otherwise-acceptable products may not always meet every requirement of the Specification. Deviations and substitutions will be considered if they are submitted in accordance with this Section (see Paragraphs 2.1F and 2.1H).

3. If there are questions or concerns, please contact the Engineer of Record for clarification.

1.2 DDC SYSTEM REQUIREMENTS

A. Open and Non-Proprietary: The DDC BAS shall be based on open standards and protocols designed to maximize interoperability and future flexibility. Any equipment, device or implementation decision which “locks in” the system to a single manufacturer or product line is not acceptable.

   1. All DDC devices shall be ANSI/ASHRAE 135 native BACnet devices.
      a. All DDC devices shall be tested, certified, clearly stamped and listed by the BACnet Testing Laboratories (BTL), or the vendor shall provide proof that the device has been submitted to BTL for testing, prior to the bid date for this Project. (Throughout this Section, any requirement that a device must be BTL-listed shall also be satisfied by proof that the device has been submitted to BTL for testing.)
      b. The BACnet operating stack must be embedded directly in each individual DDC device at the media access controller level and in all operator interface and configuration applications.
      c. The use of communication gateways, bridges, and protocol translators is restricted. See Paragraph 2.7E.

   2. BACnet devices shall not use proprietary extensions, objects, services or properties (as described in Chapter 23 of ANSI/ASHRAE 135-2016) to replace basic functions already provided by BACnet. DDC system shall use standard BACnet objects, properties, services and functions whenever practical.
      a. Exception: Proprietary extensions that provide functionality that is part of the current revision of BACnet are acceptable in devices which were BTL listed under an earlier version of BACnet which lacked the function(s) in question.

   3. If Tridium Niagara platform is to be used, it shall be open license. Station Compatibility In/Out and Tool Compatibility In/Out shall be “All”. No compatibility restrictions are acceptable.

B. Modular and Expandable:

   1. The DDC system shall be modular in nature and implemented in such a manner that it can be expanded in both capacity and functionality through the addition of DDC controllers, devices and wiring. See Paragraph 2.3G.
   2. All software assets created for the project shall be available for re-use without additional licensing or cost to the Owner. See Article 1.10.
   3. DDC System shall be designed, and licenses shall be provided, to support expansion of the DDC System to an ultimate capacity greater than that originally installed. See Paragraph 2.3G for expandability requirements.
C. Standalone Capability: Each DDC controller shall be capable of performing local control strategies without reliance upon any other controller or network. See Paragraphs 2.2E, 2.8D and 3.10B.3.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NEC with all state and local amendments, by a qualified testing agency, and marked for intended location and application.

1.3 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01, apply to this Section, except as specifically noted in this Section.

B. Product and installation requirements for electrical wiring and devices in Division 26 and Division 27 apply to this Section, except as specifically noted in this Section.

C. Related Mechanical and Controls Specifications
1. Section 23 00 00 “HVAC General Requirements”
2. Section 25 05 14 “Variable-Frequency Drives for HVAC Equipment”
3. Section 23 05 93 “Testing, Adjusting and Balancing for HVAC”
4. Section 23 08 00 “Mechanical System Commissioning”
5. Section 25 30 00 “Building Automation Sensors and Control Devices”
6. Section 25 90 00 “Building Automation System Sequence of Operations”
7. Section 26 09 13 “Electrical Power Monitoring”
8. Section 26 09 23 “Lighting Controls”

D. Related Other Specifications
1. Division 01 “Operation and Maintenance Data”
2. Division 01 “General Commissioning Requirements”
3. Section 07 84 13 “Penetration Firestopping”
4. Section 07 92 00 “Joint Sealants”
5. Section 26 05 19 “Low Voltage Electrical Power Conductors”
6. Section 26 05 23 “Control Voltage Electrical Power Conductors”
7. Section 26 05 26 “Grounding and Bonding for Electrical Systems”
8. Section 26 05 29 “Hangers and Supports for Electrical Systems”
9. Section 26 05 33 “Raceways and Boxes for Electrical Systems”
10. Section 26 05 72 “Overcurrent Protective Devices Short-Circuit Study”
11. Section 26 08 00 “Commissioning of Electrical Systems”
12. Section 26 43 13 “Surge Protection for Low-Voltage Electrical Power Circuits”

1.4 DEFINITIONS

A. Accessible: A location that can be reached with no more than a ladder to assist access and without having to remove permanent partitions or materials.

B. AHJ: The Authority Having Jurisdiction. All requirements and exceptions noted in this Section are subject to the approval of the AHJ.

C. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

D. BACnet Specific Definitions:
1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network. Unless otherwise noted, all references are to the most recent version of the standard.

2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.

3. BACnet/IP: Datalink standard that uses a reserved UDP socket to transmit BACnet messages over peer-to-peer networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.

4. BACnet MS/TP: Datalink standard that uses token passing to coordinate the transmission of BACnet messages between a master device and one or more slave devices.


6. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

E. Binary: Two-state signal where a high signal level represents “ON” or “OPEN” condition and a low signal level represents “OFF” or “CLOSED” condition. “Digital” is sometimes used interchangeably with “Binary” to indicate a two-state signal.

F. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. The three types of controllers are defined by BACnet, from most to least capable, are Building Controller, Advanced Application Controller, and Application-Specific Controller.

G. Control Network/Control LAN: Refers to any single digital data communication network used by the control system. These networks carry only control information and are distinct from the IT LAN/Owner’s LAN.

H. Control Internetwork: Refers collectively to the set of all Control Networks in the Project.

I. COV: Change of value.

J. DDC Contractor: Authorized representative of, and trained by, DDC System manufacturer and responsible for provision of DDC System and execution of Work described in this Section.

K. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

L. E/P: Voltage to pneumatic.

M. Furnish: To purchase, procure, acquire and deliver complete with related accessories. Synonymous with Supply.

N. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

O. General Contractor: The person or entity holding the master construction contract for the Project, responsible for coordinating and managing construction schedule and jobsite activities. For purposes of this Section, the term is synonymous with Project construction manager or management team.

P. Install: To erect, mount and connect complete with related accessories.
Q. Internetwork: A network of interconnected digital data communication networks. The Internet is an example of an internetwork. In the context of this Section, it refers to the entire DDC System control network including all levels of WAN and LAN.

R. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals are discrete and generally represent on/off commands, or two position operating or alarm status signals. “Digital” (DI and DO) is sometimes used interchangeably with “Binary” (BI and BO).

S. I/P: Current to pneumatic.

T. IT LAN/Owner's LAN: Refers to the Project’s Information Technology network, used for normal business-related e-mail and Internet communication. Distinct from control networks.

U. LAN: Local area network, a digital data communication network typically confined to a single building or small campus.

V. Low Voltage: As defined in NEC with all state and local amendments for circuits and equipment operating at less than 50 V or for remote-control, power-limited signaling circuits.

W. Mobile Computing Device: A portable device with display, input and wireless networking capabilities. Includes “smart” mobile phones and tablet devices running iOS or Android operating systems.

X. Modbus: An open protocol for exchange of process data.

Y. MS/TP: Master-slave/token-passing, per IEEE 8802-3. A network protocol that uses twisted pair wire for low-speed communication.

Z. NiCS: Niagara Compatibility Statement

AA. Operator’s Interface Device: Provides the Operator with the ability to interact with the DDC System. Specifically a hardware device.

BB. Operator’s Workstation: A computer that provides the user’s interface with the DDC System. May also refer to the user interface software package, whether hosted on a controller or on a PC.

CC. Owner: The Project Owner or their designated Representative who is empowered to make decisions regarding the project. The Commissioning Authority is not the Owner’s Representative unless they have been specifically empowered to make project decisions by the Owner in writing.


EE. Peer to Peer: Networking architecture that treats all network stations as equal partners.

FF. POT: Portable Operator's Terminal, a handheld operator interface device with integral keypad or touch screen, designed specifically for interface with DDC System by a technician in the field.

GG. Provide: Furnish and Install, complete and ready for safe and regular operation.

HH. Router: Device connecting two or more networks at network layer.
II. Request-based Trim & Respond logic: A reset scheme that periodically resets the setpoint at an “upstream” system (e.g. air handler) using demand-based Requests from “downstream” devices (e.g. terminal units). The setpoint is adjusted at a defined, user-adjustable time-step frequency. Downstream devices can be made to have more or less impact on the reset by adjusting the device’s Importance multiplier (default = 1). For more detail and a worked example, see Sequences of Operations.

JJ. Supply: To purchase, procure, acquire and deliver complete with related accessories. Synonymous with Furnish.

KK. System Software: Refers to software providing engineering, operator’s interface, configuration/programming, and data collection/analysis functions. System Software functions may be provided by a single or multiple pieces of software, hosted on a variety of platforms.

LL. TAB: Test and Balance, a process to establish air and water flow rates at terminal units, systems, plants, control devices and other equipment. The TAB Contractor works with DDC Contractor to establish field-determined setpoints as described in the Sequences of Operations.

MM. TCP/IP: Transport Control Protocol/Internet Protocol, a suite of protocols that routes data through a network of networks to provide a host with access to the Internet.

NN. UPS: Uninterruptible power supply.

OO. USB: Universal Serial Bus.

PP. WAN: Wide area network, a telecommunications network that extends over large geographic distances, such as connecting multiple buildings or campuses in disparate locations.

QQ. Wiring: Refers to wire and cable, and also raceways, fittings, conduit, boxes, and related items.

RR. Work: Labor, materials, equipment, apparatus, controls, accessories, etc. Everything that is required for proper and complete installation.

SS. Zone/Control Zone: A defined indoor area that is controlled to maintain specified temperature or airflow. Zone maps shall be provided with Contract Drawing mechanical plans for each type of zone relevant to the Project. Different types of zones may overlap completely, or may be distinct, depending on the mechanical design being employed.

1. Radiant Control Zone: A portion of the building’s mass, typically floor or ceiling, which is controlled to a temperature setpoint based on temperature measurement by a slab-embedded sensor.

2. Thermal Space Control Zone: An indoor space (i.e. room or part thereof) in which the air temperature is controlled to a setpoint based on temperature measurement by a thermostat or space sensor.

3. Ventilation Control Zone: An indoor space in which the airflow and/or outdoor air rate is controlled to maintain adequate ventilation or prevent elevated CO₂ levels.

4. If only one zone map is provided with mechanical plans, it shall be assumed unless otherwise indicated to represent Thermal Space and Ventilation Control Zones which overlap completely. (This is typical for VAV systems, but not necessarily for other system types.)
1.5 CODES AND STANDARDS

A. Workmanship, materials and equipment together with the resultant complete and operational DDC System shall be in compliance with the Authorities Having Jurisdiction (AHJ) for the Project and the most restrictive of applicable local, state and federal codes and ordinances in cooperation with these plans and Specifications.

B. At a minimum, the installation shall comply with the applicable Sections of the current editions in effect thirty (30) days prior to receipt of bids of the following codes:
   1. ANSI/ASHRAE Standard 135: Data Communication Protocol for Building Automation and Control Networks (BACnet)
   3. California Code Title 24, if Project is located in California.
   4. International Building Code (IBC), for Projects outside of California
   5. International Mechanical Code (IMC), for Projects outside of California
   6. National Electric Code (NEC) with all state and local amendments
   7. Telecommunications Industry Association (TIA):
      a. ANSI/TIA-568-C.0: Generic Telecommunications Cabling for Customer Premises
      b. ANSI/TIA-568-C.1: Commercial Building Telecommunications Cabling Standards
      c. ANSI/TIA-568-C.2: Balanced Twisted Pair Telecommunications Cabling and Components
      d. ANSI-TIA-607-B: Generic Telecommunications Bonding and Grounding for Customer Premises
   8. Underwriters Laboratories (UL)
      a. UL-50: Enclosures for Electrical Equipment
      b. UL-508A: Industrial Control Panels
      c. UL-916: Energy Management Equipment

1.6 QUALIFICATIONS AND QUALITY ASSURANCE

A. Competitive Bidding
   1. To encourage competitive bidding and protect the Owner from vendor lock-in, only product lines with multiple installer/contractor options are permitted to bid on this spec.

B. DDC System Manufacturer Qualifications:
   1. Nationally recognized manufacturer of DDC systems and products from approved manufacturers listed in Article 2.1.
   2. Has produced DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
   3. DDC systems and products that have been successfully tested and in use on at least ten past Projects of comparative size and complexity.
   4. Has complete published catalog literature, installation, operation and maintenance manuals for all products intended for use.
   5. Has full-time in-house employees for the following:
      a. Product research and development.
      b. Product and application engineering.
      c. Product manufacturing, testing and quality control.
      d. Technical support for DDC system installation training, commissioning and troubleshooting of installations.
e. Owner operator training.

6. All products used in this installation shall be new and currently under manufacture. Spare parts shall be available for at least five years after completion of this contract.

7. All products shall have been available from the manufacturer for a minimum of 6 months prior to date of proposal and previously installed and proven effective in installations of similar nature, not including test sites. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner in writing.

8. All BACnet devices must either be certified as compliant with the BACnet standard through a listing by the BACnet Testing Laboratory (BTL) or the vendor must supply proof of having submitted the device for testing by BTL.

9. The DDC system and components shall be listed by Underwriters Laboratories UL 916 as an Energy Management System.

10. Manufacturer shall be ISO 9001 registered.

C. DDC Contractor Qualifications:

1. Authorized representative of, and trained by, DDC System manufacturer.

2. Contractor’s Project Manager Qualifications: Individual shall specialize in and be experienced with direct digital control system installation for not less than 3 years. Project Manager shall have experience with the installation of the proposed direct digital control equipment product line for not less than 2 Projects of similar size and complexity.

3. Contractor’s Programmer Qualifications: Individual(s) shall specialize in and be experienced with direct digital control system programming for not less than 3 years and with the proposed direct digital control equipment product line for not less than 1.5 years. Programmers must show proof of having successfully completed the most advanced programming training offered by the vendor of the programming application on the proposed product line.

4. Contractor’s Service Qualifications: The installer must be experienced in control system operation, maintenance and service. Contractor must document a minimum 5-year history of servicing installations of similar size and complexity. Installer must also document at least a 1-year history of servicing the proposed product line.

5. Contractor’s Response Time and Proximity

a. Installer must maintain a fully capable service facility within 50 miles of the subject Project. Service facility shall manage the emergency service dispatches and maintain the inventory of spare parts.

b. Installer must demonstrate the ability to meet the emergency response times listed in Paragraph 1.12B.1.

6. Electrical installation shall be by manufacturer-trained electricians

a. Exception: Roughing in wiring and conduit and mounting panels may be subcontracted to any licensed electrician.

b. Exception: Installation of low voltage power and signal wiring may be performed by contractors who are not licensed electricians, if permitted by local code, the General Contractor, and the AHJ.

7. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.

8. Service and maintenance staff assigned to support Project during warranty period.

9. Product parts inventory to support on-going DDC system operation for a period of not less than five years after completion of Work.

D. Instruments for Calibration and Testing

1. All instruments required for field calibration, verification and testing of control devices, except for terminal unit balancing, shall be provided by the DDC Contractor.
2. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.
3. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (for example if field device is ±0.5% accurate, test equipment shall be ±0.25% accurate over same range).

1.7 MEETINGS

A. Preinstallation Meetings: At Engineer’s option, Contractor shall attend pre-installation meetings at Project site or Engineer’s office
   1. Before preparing DDC shop drawings
   2. Before commencing installation.

B. Commissioning Meetings: Contractor shall attend all commissioning meetings where their presence is requested by the General Contractor, the Commissioning Authority or the Engineer of Record. See Article 3.16.

1.8 SUBMITTALS

A. No work may begin on any segment of this Project until the related submittals have been reviewed for conformity with the design intent and the Contractor has responded to all comments to the satisfaction of the Engineer of Record.

B. Submit drawings and product data as hereinafter specified. Requirements of this Article supersede and take precedence over conditions in Division 1 or Division 23.

C. Submittal documentation and drawings shall consistently use the same abbreviations, symbols, nomenclature and identifiers.

D. Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BMS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Owner, and include with O&M/Closeout documentation.

E. Submittals shall be provided in digital format.
   1. Provide a separate file for each submittal. For submittal packages, provide a separate file for each subsection (e.g. for Submittal Package 1, hardware cutsheets and shop drawings shall be provided as separate files).
   2. Product cutsheets, test forms and other text documents shall be provided in word-searchable digital format. Acceptable formats are MS Word, PDF (generated from another electronic document and word-searchable; scans of paper documents are not acceptable), and HTML; other formats require approval prior to submission.
   3. For submittals, drawings and schematics shall be provided in PDF format. For completion documents, drawings shall be provided in both PDF and AutoCAD-compatible format.
   4. Sequences of operations shall be submitted in MS Word format.
   5. Scanned paper documents are not acceptable
      a. Exception: original signed documents, such as qualifications, inspection certificates, and warranty documents.
   6. Hardcopy (paper) submittals are not acceptable and shall not be provided except as noted in Closeout Submittals (see Paragraph 1.9B).
   7. Submittals provided in the wrong format will be returned without action.
F. Submission and Resubmission Procedure

1. Optional Pre-Submittals: At DDC Contractor’s option, electronic submittals indicated below may be submitted unofficially via email directly to the Engineer of Record for review and comment prior to formal submission. Comments provided by the Engineer are not official and may be changed or additional comments may be provided on the formal submittal. The intent of pre-submittals is to reduce paperwork and review time, and to provide a venue to discuss technologies, products, designs or implementation strategies that are novel or unique.

2. Each submittal shall have a unique serial number that includes the associated Specification Section followed by a number for each sub-part of the submittal for that Specification Section, such as SUBMITTAL 255000-01. There is no requirement to assign particular serial numbers to any specific submittals – serial number assignment is arbitrary. The only requirements are that the serial numbers be sequential (to avoid confusing gaps) and, most importantly, **consistent across all submittal correspondence**.

3. Each resubmittal shall have the original unique serial number plus unique revision number such as SUBMITTAL 255000-01 REVISION 1.

4. Submit one copy of submittal in electronic format specified under each submittal package below. Submissions made in the wrong format will be returned without action.

5. Revise submittal
   a. Respond to all comments:
      1) Revise initial submittal to resolve review comments and corrections.
      2) Provide complete responses to comments or suggestions which are, in the opinion of the DDC Contractor, not practical to implement.
   b. Indicate any changes that have been made other than those requested.
   c. Clearly identify resubmittal by original submittal number and revision number.
   d. Resubmittals that are not responsive to all comments will be returned without action.

6. Resubmit revised submittals until no exceptions are taken.

7. Once submittals are accepted with no exceptions taken, provide
   a. Complete submittal of all accepted drawings and products in a single electronic file.
   b. Copies for coordination with other trades, if and as required by the General Contractor or Owner’s Representative.

G. Submittal Schedule:

1. Submittal schedule shall be as follows unless otherwise directed by the Owner’s Representative. Each entry in the following list is a separate submittal (some are “packages” of multiple items as described in the next paragraph, while others are individual items):
   a. Submittal Package 0 (Qualifications) shall be submitted with bid.
   b. Submittal Package 1 (Hardware and Shop Drawings) shall be submitted in accordance with schedule established by General Contractor or in bid documents.
   c. Submittal Package 2 (Programming and Graphics) and shall be submitted no less than 30 days before software is to be installed in field devices.
      1) Submit Site Conditions Report per Paragraph 3.3D as early as practical, but no later than Submittal Package 2.
   d. Submittal Package 3 (Testing Forms) shall be submitted no less than 3 weeks prior to beginning Pre-Functional Tests.
   e. Submit BAS Pre-Functional Test Report (Paragraph 3.16C) as soon as it is complete.
   f. Submit Setpoint Determination Report (Paragraph 3.16D.3) as soon as it is complete. Do not perform setpoint determination process until Pre-Functional Tests have been reviewed and accepted.
g. Submit BAS Functional Test Report (Paragraph 3.16E) as soon as it is complete. Do not perform Functional Tests until Setpoint Determination Report has been reviewed and accepted.

h. Submittal Package 4 (Training Materials) shall be submitted no less than 21 days prior to conducting first training class.

i. Submittal Package 5 (Post-Construction Trend Logs) shall be submitted after demonstration tests are accepted and systems are in full automatic operation. The list of points to be trended shall be submitted for approval 14 days prior to the start of the trend collection period.

2. All DDC submittals are considered “large and complex” as defined in General Requirements for Division 23. Allow 15 working days for review, unless Engineer of Record agrees to accelerated schedule in writing. This supersedes the submittal review period defined in Division 01.

3. If Project schedule requires deviation from this schedule, DDC Contractor shall provide notice along with a proposed alternative schedule including expected dates for each submission.

4. Submittal Package 6 (End-of-Warranty Trend Logs) shall be submitted 30 days prior to the end of the warranty period.

H. Submittal Packages

1. Submittal Package 0 (Qualifications)
   a. Provide DDC System manufacturer qualifications as specified in Paragraph 1.6A.
   b. Provide DDC Contractor and key personnel qualifications as specified in Paragraph 1.6C, including
      1) Names and resumes of key personnel assigned to the Project
      2) Brief description of qualifying past Projects including physical address, floor area, number of floors, building system cooling and heating capacity and building’s primary function
      3) Description of qualifying past Projects’ DDC systems, noting similarities to Project scope and complexity indicated
      4) Owner, engineer and contractor contact information for qualifying past Projects, including name, phone number and email address
   c. Format: Word-searchable format per Paragraph 1.8E.

2. Submittal Package 1 (Hardware, Shop Drawings, Coordination Plans, Schedule)
   a. Hardware
      1) Organize by Specification sub-Section and device tags as shown on Contract Drawings.
      2) Do not submit products that are not used even if included in Specifications.
      3) Include a summary table of contents listing for every submitted device:
         a) Tab of submittal file/binder where submittal is located
         b) Specification Paragraph, down to the lowest applicable heading number.
         c) Whether device is per Specifications or deviates from Specification.
         d) Whether device is a listed product or a substitution.
         e) Manufacturer
         f) Model number
         g) Device accuracy (where applicable)
         h) Accuracy as installed including wiring and A/D conversion effects (where applicable)
      4) Submittal shall include manufacturer’s description, product Specification sheets and complete technical data, including
a) For BACnet networked products, BTL-listed Protocol Implementation Conformance Statement (PICS) including a BACnet Interoperability Building Block (BIBB) table for each DDC device. Manufacturer-provided PICS which include features not certified by BTL or submitted to BTL for testing are not acceptable.

b) If Tridium Niagara platform is to be used, Niagara Compatibility Statement (NiCS) attesting that open-license Niagara shall be installed per Paragraph 1.2A.3.

c) Construction details, material descriptions, dimensions of individual components and profiles, and finishes

d) Operating characteristics

e) Electrical characteristics and power requirements

f) Performance curves

g) Operating range

h) Accuracy and repeatability over range

i) Control signal range

j) Default condition upon loss of power

k) Calibration data if applicable

l) Environmental operating conditions and limits

m) Furnished accessories

n) Operation and maintenance instructions including factors effecting performance.

5) Submit on all required System Software Functions (Article 2.4) whether those functions are provided by a software application, a dedicated appliance, or are embedded in a controller.

6) Note all deviations from this Section, per Paragraph 2.1F.

7) If product is a substitution, provide additional information as required in Paragraph 2.1H.

8) Each submitted piece of literature and drawings shall clearly reference the drawing sheet or Paragraph of this Section that the submittal is to cover.

   a) When manufacturer’s cut-sheets apply to a product series rather than a specific product, the data specifically applicable to the Project shall be highlighted or clearly indicated by other means.

   b) General catalogs shall not be accepted as cut sheets to fulfill submittal requirements.

9) Format: Word-searchable format per Paragraph 1.8E.

b. Shop Drawings

1) System architecture one-line diagram indicating schematic location of all control devices, workstations, LAN interface devices, gateways in addition to the following information:

   a) Data link of each LAN with physical characteristics and configuration.

   b) Each networked DDC device including location, service, device instance, MAC address and network number.

   c) Each IP networking device including location, service and IP address.

   d) Location of all interface devices including network interface jacks and workstation connections.

   e) Location of all MS/TP network termination points and end-of-line terminations.

2) Schematic flow diagram of each air and water system showing equipment and control devices. The schematics provided on Contract Drawings shall be the basis of the schematics with respect to layout and location of control points.
a) All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the Point Summary Table (see Paragraph 3.10D). Label each input and output with the appropriate range.

3) Bill of Materials: With each schematic, provide a table of all equipment, controllers, devices and sensors to be provided and/or used including:
   a) Device tag as indicated in the schematic and used in actual field labeling.
   b) Device tag as indicated in the Contract Drawings if it differs from schematic device tag
   c) Description
   d) Proposed manufacturer and model number
   e) Range
   f) Quantity

4) In Bill of Materials or on a separate sheet, provide a schedule of all control valves including the unique equipment identifier, valve size, dimensions and installation/maintenance clearance, model number, close-off rating, flow, CV, pressure drop, pressure rating and location. The valve schedule shall also contain actuator selection data supported by calculations of the force required to move, close and seal the valve at design conditions. Indicate normal positions of fail-safe (i.e. spring-return) valves.

5) In Bill of Materials or on a separate sheet, provide a schedule of all control dampers. This shall include the unique equipment identifier, damper size, pressure drop, blade configuration, orientation and axis of frame, blade rotation, location and selection criteria of actuators, nominal and actual sizes, and manufacturer and model number. Indicate normal positions of fail-safe (i.e. spring-return) dampers.

6) Physical details for each control panel and/or enclosure, drawn to scale and showing all internal components, including controls, instruments, wiring and labeling. Indicate panel installation locations in plan and elevation.

7) Electrical schematic for each control panel and/or enclosure showing each point of connection and/or product requiring power with requirements (volts/amps/connection type) listed for each. Show all control power supplies including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
   a) Electrical wiring diagrams shall include ladder logic type diagram for motor starter, control, and safety circuits
   b) Electrical wiring diagrams shall include detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified.
   c) Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

8) Wiring diagrams for all packaged equipment indicating all interconnecting wiring and termination of all wires including labels and point names.

9) Wiring diagrams and schematics for each sensor.

   c. Master Point Summary Table: Provide in Excel format per Paragraph 3.10D.4.
   d. Network performance: Document memory allocation projections and calculated and guaranteed system response times of the most heavily loaded LAN in the system. Submitted network shall be able to pass network performance tests described in Paragraph 3.16C.6.d.
e. Schedule of Work: Provide a schedule indicating at a minimum the intended sequence of work, start dates and durations for individual activities, delivery dates for major materials and equipment including anticipated lead times and milestones indicating possible restraints on work by other trades or construction delays.

f. Coordination Plans: Submit coordination plans as required in Article 3.4.

1) Submit all coordination plans with this submittal, except TAB coordination plan (Paragraph 3.4F.3) which is submitted with DDC Submittal Package 2, described below.

g. Do not include sequence of operations or control programming on shop drawings or equipment submittals; they are included in DDC Submittal Package 2, described below.

h. Format (see Paragraph 1.8E)

1) Provide table of contents.
2) Sheets shall be consecutively numbered.
3) Each sheet shall indicate name and location of Project.
4) Each sheet shall have a title indicating the type of information included and the mechanical/electrical system controlled.
5) Each Section shall have a title indicating the type of information being submitted.
6) Include legend and list of abbreviations.
7) Text documents (narratives and lists): Word-searchable format, ANSI A size.
8) Schedule of Work: Narrative text document or full-color Gantt chart, in PDF format.
9) Schematics: Word-searchable PDF format, ANSI B or ANSI C size.
10) Drawings, if applicable: AutoCAD-compatible format, ANSI B or ANSI C size.

3. Submittal Package 2 (Programming and Graphics)

a. A detailed description of point naming convention conforming to Paragraph 3.10C, to be used for all software and hardware points. Naming convention shall integrate with existing database, if applicable.

b. A list of all hardware and software points identifying their full text names, device addresses and descriptions.

c. Control Logic Documentation

1) To facilitate this submittal, a digital, searchable and cross-referenced version of the Sequences of Operations will be provided to the DDC Contractor upon request to the Engineer of Record.

2) Submit control logic program consistent with specified English-language Sequences of Operation for all control units.

a) Control logic programming shall be visual logic programming if that is used by the control system, line code otherwise.

b) Control logic shall be annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow an operator to relate each program component (block or line) to corresponding portions of the specified Sequence of Operation.

3) Submit as-programmed English-language Sequences of Operation with each control sequence updated to reflect any suggested changes made by the DDC Contractor. **Changes shall be clearly marked.** SOO shall be fully consistent with submitted programming.

a) All changes to SOO require review and approval of the Engineer of Record. DDC Contractor is strongly encouraged to provide an informal pre-submittal (see Paragraph 1.8F.1) of suggested or desired changes to control sequence logic.
b) Changes which are inconsistent with the intent of the SOO or may negatively impact energy consumption or occupant comfort are not acceptable and will be rejected.

c) Only SOO reviewed and accepted by the Engineer of Record shall be installed in DDC System.

4) Include control settings, setpoints, throttling ranges, reset schedules, adjustable parameters and limits.

5) Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation.

d) Graphic screens of all required graphics, provided in final colors. Provide flowchart, page map, or other means of indicating how screens are related to each other and how operator is intended to navigate between them.

e) Description of points database, including database capacity and any limitations to expansion of database.

f) Description of trend archive database, including database capacity and any limitations to expansion of database.

g) Description of system operation under potential failure conditions, including:

   1) Loss of power.
   2) Loss of network communication signal.
   3) Loss of controller signals to inputs and outputs.
   4) Operator workstation failure.
   5) Server failure.
   6) Gateway failure.
   7) Network failure.
   8) Controller failure.
   9) Instrument failure.

h) Site Conditions Report per Paragraph 3.3D if not previously submitted.

i) Format

   1) Coordination plan: Word-searchable format per Paragraph 1.8E.
   2) Points list: Word-searchable format per Paragraph 1.8E.
   3) As-programmed Sequences of Operation: Microsoft Word format per Paragraph 1.8E.
   4) Programming

      a) Graphical programming: Native electronic file if interpreter is freely available (e.g. ALC Eikon); otherwise provide digital image (JPG, PNG, etc.) or PDF document of screens.

      b) Line code programming: Word-searchable format per Paragraph 1.8E.

   5) Programming and operating manual: Word-searchable electronic format per Paragraph 1.8E.

   6) Graphics: Digital images (JPG, PNG, etc.) or PDF document.

4. Submittal Package 3 (Testing Forms)

   a). Provide Pre-Functional Test forms (Paragraph 3.16B.1) for approval.

   b) Provide Setpoint Determination coordination plan and forms as required by Paragraphs 3.16B.2 and 3.4F for approval.

   c) Provide review of Functional Test forms (Paragraph 3.16B.3) for approval.

   d) Format: Word-searchable format per Paragraph 1.8E.

5. Submittal Package 4 (Training Materials)

   a) Provide training materials as described in Article 3.17.

   b) Format: Word-searchable format per Paragraph 1.8E.
6. Submittal Package 5 (Post-Construction Trend Test)
   a. Provide a list of points being trended and trend basis (time frequency or change-of-value). See Paragraph 3.6E for initial trends.
   b. Provide trend logs as required by Paragraph 3.16G.
   c. Format shall be XLS or CSV, organized as described in Paragraph 3.16G.2.d.

7. Submittal Package 6 (End-of-Warranty Trend Test)
   a. Provide a list of points being trended and trend basis (time frequency or change-of-value). Create a new list – do not simply re-use list provided with Submittal Package 5 – to ensure that any changes in trend logging are captured.
   b. Provide trend logs as required by Paragraph 3.16G.
   c. Format shall be XLS or CSV, organized as described in Paragraph 3.16G.2.d.

1.9 COMPLETION REQUIREMENTS

A. Procedure
   1. Until the documents required in this Section are submitted and accepted, the system will not be considered accepted and final payment to DDC Contractor will not be authorized.
   2. Before requesting acceptance of Work, submit one set of completion documents in digital format only for review and approval by Engineer of Record and by Commissioning Authority or Owner’s Representative.
   3. After review, furnish quantity of sets (digital and hardcopy) indicated below to Owner.

B. Documents. Provide in both paper and electronic format per Paragraph 1.9C
   1. Operation and Maintenance (O&M) Manuals: In addition to items specified in Division 1 and Division 23, include the following:
      a. Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual.
      b. As-built versions of submittal shop drawings
      c. As-built versions of submittal product data
      d. As-built network architecture drawings showing all BACnet nodes including specific controller and device identification, description and location information.
      e. As-built Point Summary Table per Paragraph 3.10D
      f. English language Sequences of Operations updated to reflect final programming installed in the DDC System at the time of system acceptance.
      g. A BACnet Protocol Implementation Conformance Statement (PICS) for each type of controller and operator interface.
      h. Names, addresses, e-mail addresses and 24-hour telephone numbers of DDC Contractor and service representatives for DDC system and products.
      i. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
      j. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
      k. Engineering, installation, and maintenance manuals that explain how to:
         1) Design and install new points, panels, and other hardware
         2) Perform preventive maintenance and calibration
         3) Debug hardware problems
         4) Repair or replace hardware
l. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.

m. A copy of the Setpoint Determination Report per Paragraph 3.16D.3 which reflects the work described in the coordination plan (Paragraph 3.4F.3). Do not include the entire TAB Contractor’s report; include only those Sections related to the parameters used for control.

dl. List of recommended spare parts with part numbers and suppliers.

m. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

n. Licenses, guarantees, and warranty documents for all equipment and systems, including the start and end date for each.

o. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

p. Training materials as described in Article 3.17

2. Original issue CDs/DVDs for all software provided, including operating systems, programming language, operator workstation software, and graphics software. “Burned” copies of commercial software discs are not acceptable.

3. Complete copy of DDC System databases, user screens, graphics, setpoints and all configuration settings. Include all data necessary to recover from complete loss of server and/or controller programming, and to restore the DDC System in the same configuration as at the time of system acceptance.

4. Access Credentials: Provide usernames and passwords required to log into DDC System at all defined access levels (administrator, operator, etc.), as coordinated with Owner. Default passwords shall not be used. See Paragraph 2.4A.6.

5. Commissioning Reports: Completed versions of all Pre-functional, Functional, and Demonstration Commissioning Test reports, calibration logs, etc., per Article 3.16.

6. Copy of inspection certificates provided by the local code authorities.

C. Format of Completion Documents

1. Provide the type and quantity of media listed in table:

<table>
<thead>
<tr>
<th>Document</th>
<th>Paper (binder or bound)</th>
<th>Digital Archive DVD (see 1.9C.2)</th>
<th>On Data Archive Server</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Record Drawings</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>O&amp;M Manual</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Original issue software</td>
<td>–</td>
<td>1 per workstation</td>
<td>1</td>
</tr>
<tr>
<td>Project database including all source files</td>
<td>–</td>
<td>1 per workstation</td>
<td>1</td>
</tr>
<tr>
<td>Sequences of Operations</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Access Credentials</td>
<td>1 (see Paragraph 1.9C.4)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Commissioning Reports</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Inspection Certificates</td>
<td>1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Warranty Documents</td>
<td>1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Training Materials</td>
<td>1 per trainee</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Contact Information</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
2. If Data Archive Server is “Not Required” per Article 2.6, disregard that column in the table above. If Data Archive Server is included, all information listed above shall be stored on the Data drive.

3. Archive DVD shall use Verbatim UltraLife Gold Archival Grade DVD-R. Other brands of DVD, or the use of thumb drives, are not acceptable, as those media are not suitable for long-term data storage.

4. Access credential information shall be provided in hardcopy in a marked, sealed envelope directly to Owner, Owner’s designated representative, building stationary engineer, or head of maintenance. Obtain signed receipt for transfer of credential information.

5. Project database, programming source files, and all other files required to modify, maintain, or enhance the installed system shall be provided in their source format and compiled format (where applicable).

6. Where digital copies are specified, comply with the format requirements in Paragraph 1.8E.
   a. Drawings and schematics shall be provided in both PDF and AutoCAD-compatible format.

D. Permanent on-site documentation: For each control panel or enclosure, provide documentation as required by Paragraph 3.12B.4.b.

1.10 OWNERSHIP OF PROPRIETARY MATERIALS

A. All Project-developed software and documentation shall become the property of the Owner. These include, but are not limited to:
   1. Project graphic images
   2. Record drawings
   3. Project database
   4. Project-specific application programming code
   5. All trend and runtime data
   6. All reports prepared from DDC System trend or runtime data
   7. All documentation

B. All software tools, including programming, graphics, and documentation associated with the Project, or required for maintenance, configuration, expansion, or troubleshooting, shall be provided at no additional cost to the Owner.

C. If any software is limited by time-period (e.g., annual) license or subscription:
   1. Provide software with a license for a minimum of 5 years as part of the base bid.
   2. License shall permit unlimited use of all features required by this Section and/or available upon installation for the duration of the license.
   3. License shall support expansion of the DDC System to an ultimate capacity greater than that originally installed. See Paragraph 2.3G for expandability requirements.
   4. Clearly indicate in bid which software is so licensed, the time period of the license (annual, etc.) and the periodic licensing fee that will be required after the initial five years.

D. The Owner shall be the named license holder of all software associated with the execution of this Project, or required for future maintenance, configuration, expansion, or troubleshooting.
1.11 WARRANTY

A. At the successful completion of the final testing, commissioning, and demonstration phase in accordance with the terms of this Specification, if equipment and systems are operating satisfactorily to the Owner and if all completion requirements per Paragraph 1.9 have been fulfilled, the Owner shall certify in writing that the DDC System has been accepted. The date of acceptance shall be the start of the warranty period.

1. The DDC System warranty period shall be independent of the warranty period for other building systems. Neither “substantial completion”, “beneficial use” nor the certificate of occupancy shall necessarily be deemed as the start of the DDC System warranty period. The start of the warranty period shall depend solely upon the acceptance of the completion requirements as outlined above.

B. Guarantee all materials, equipment, apparatus and workmanship (including programming) to be free of defective materials and faulty workmanship for at least the following periods from date of acceptance:

1. Controllers (BCs, AACs, and ASCs), routers and gateways: two years
2. Valve and damper actuators: two years
3. Temperature, humidity, and CO\textsubscript{2} sensors: five years
4. Programming: one year
5. All else: one year

C. Provide new materials, equipment, apparatus and labor to replace that determined by Owner to be defective or faulty.

D. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. Contractor shall respond to the Owner’s request for warranty service within 24 hours during normal business hours.

E. Operator workstation software, Project-specific software, graphic software, database software, and firmware updates that resolve known software deficiencies shall be provided at no cost to the Owner during the programming warranty period.

F. Sequence of operation programming bugs (both due to programming misinterpretations and sequence errors) shall be corrected and any reasonable control sequence changes required to provide proper system operation shall be provided at no additional cost to the Owner during the programming warranty period.

G. For equipment with manufacturer’s warranty in excess of DDC System warranty periods described above, DDC Contractor shall provide Owner with original manufacturer’s warranty certificates.

1.12 WARRANTY MAINTENANCE

A. The Owner reserves the right to make changes to the DDC System during the warranty period. Such changes do not constitute a waiver of warranty. The DDC Contractor shall warrant parts and installation work regardless of any such changes made by the Owner, unless the DDC Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the DDC System.

B. At no cost to the Owner, provide services for software and hardware components during the warranty period as specified below:
1. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following notification by the Owner to the DDC Contractor.
   a. Response by telephone or via internet connection to the DDC System to any request for service shall be provided within two hours of the Owner’s initial request for service.
   b. In the event that the malfunction, failure, or defect is not corrected, at least one technician, trained in the system to be serviced, shall be dispatched to the Owner’s site within eight hours of the Owner’s initial request for such services.

2. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following notification by the Owner to the Contractor.
   a. Response by telephone or via internet connection to the DDC System to any request for service shall be provided within eight working hours of the Owner’s initial request for service.
   b. In the event that the malfunction, failure, or defect is not corrected, at least one technician, trained in the system to be serviced, shall be dispatched to the Owner’s site within three working days of the Owner’s initial request for such services, as specified.

3. Service Telephone Numbers: Contractor shall specify a maximum of three telephone numbers for Owner to call in the event of a need for service. At least one of the lines shall be attended continuously (24/7). Alternatively, pagers/SMS can be used for technicians trained in system to be serviced. One of the three paged/texted technicians shall respond to every call within 15 minutes.

4. Technical Support: Contractor shall provide technical support by telephone throughout the warranty period.

5. Documentation: Record drawings and software documentation shall be updated as required to reflect any and all changes made to the system or programming during the warranty period.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the requirements of this Specification, provide products by the following manufacturer:
   1. Automated Logic Corporation: www.automatedlogic.com

B. To encourage competitive bidding and protect the Owner from vendor lock-in, only product lines with multiple installer/contractor options are permitted to bid on this spec. DDC manufacturers and/or contractors with exclusive territories that restrict bidding to a single installer within the project’s geographic region are not acceptable.

C. All DDC System networked devices specified herein including controllers, routers, and software shall be provided by one of the manufacturers listed above.
   1. OEM and/or private-labelled controllers, or software, developed by a third party and labelled or otherwise represented as being a product of one of the allowable manufacturers listed above shall not be accepted.
2. Non-networked system components specified herein (including sensors, valves, dampers, etc.) need not be manufactured by the above manufacturers.

D. The DDC System product line selected shall be the most current and complete offering from the manufacturer and shall currently be actively manufactured and supported at the time that this Project is bid.
   1. This Project shall not be used as a test site. First release and test version hardware, software and firmware shall not be used on this Project under any circumstances.

E. DDC System devices and spare components or equivalent shall be readily available for a minimum of five (5) years after the completion and final acceptance of this Project.

F. Deviations from Specification
   1. DDC Contractor shall thoroughly review this specification and note all items which do not comply with the listed requirements.
   2. For each item not fully in compliance, DDC Contractor shall provide a brief narrative describing the discrepancy. Include for each item a reference to the applicable paragraph of this document.
   3. Document all deviations from this Section.
      a. In general, deviations which do not compromise the performance, efficiency, or interoperability goals of the Project will be permitted.
      b. All deviations must be documented at this time. Deviations discovered later in the Project process, particularly after installation has begun, shall not be accepted.
      c. Acceptance or rejection of deviations from the requirements of this Section is at the discretion of the Engineer of Record.
   4. Include review and narratives with Submittal Package 1.

G. DDC Contractor Feedback
   1. DDC Contractor may at their option provide comments and feedback about elements of this and other Division 25 Sections which are in his/her opinion onerous, adding unnecessary cost, or potentially reducing the quality or efficiency of the DDC System. Contractor is encouraged to suggest alternative solutions.
   2. Items so noted will be reviewed by the Engineer of Record. Suggestions which do not compromise the performance, efficiency or interoperability goals of the Project may be accepted by the Engineer of Record.
   3. Requests to allow networked devices or control systems that are not fully BACnet compliant will not be accepted.
   4. If Engineer of Record does not respond to feedback/suggestions, this shall not be taken as a sign of acceptance. Unless explicitly indicated in writing by Engineer of Record, DDC Contractor is responsible for meeting all requirements of this and related Sections, regardless of perceived difficulty or cost.
   5. Include comments and feedback with Submittal Package 1.

H. Substitutions
   1. Substitutions shall be considered only after an extensive function-by-function comparison, additional reference checks, and the approval of the Engineer of Record.
   2. If DDC Contractor wishes to provide product from a manufacturer not listed in this Part of the Section, submit the following information to support the product under consideration:
      a. Product details: Submit complete documentation of the product. Provide literature, cutsheets etc. that document the product’s compliance with all relevant codes, standards, certifications, and listings required per this Section. Provide explanations for any requirements which cannot be substantiated from product literature.
b. Comparison: Submit extensive and detailed comparison of the product relative to this Section. Submit a copy of the applicable portions of this Section, with a note or comment for each requirement, indicating whether the proposed product complies or suggesting why compliance with a particular requirement is not necessary or appropriate for the needs of the design and the Project.

c. References: Ten completed buildings that are comparable in size, principal occupancy, climate type, and system types which have successfully utilized the product.

d. Substitution requests which are not accompanied by adequate documentation per this Paragraph shall be returned without further action.

3. All requested substitutions shall be submitted with Submittal Package 1.

4. DDC Contractor shall not supply or install any hardware or software that is a substitution relative to the basis of design without written approval from the Engineer of Record.

2.2 PERFORMANCE REQUIREMENTS

A. Environmental Conditions

1. All DDC System components provided under this Specification shall operate under ambient environmental conditions of 32°F to 122°F dry-bulb and 10% to 90% relative humidity, non-condensing as a minimum.

   a. It is the DDC Contractor’s responsibility to identify locations subject to more extreme conditions, particularly rooftop and outdoor installations, and provide products suitable for those locations.

2. Sensors and control elements shall be constructed of material suitable and rated for the media sensed under the ambient environmental temperature, pressure, humidity, and vibration conditions encountered for the installed location.

3. Power Conditions: Networked components of the DDC System shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%.

4. Noise Immunity: Networked components of the DDC System shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 watts power located within 36 inches of device or enclosure.

B. DDC System Speed

1. The communication speed between the controllers, routers, and operator interface devices shall be sufficient to ensure fast system response time under all loading conditions, including during collection of specified trend data.

   a. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein, assuming no other simultaneous operator activity.

   b. Reconfigure LAN or provide additional capacity as necessary to accomplish these performance requirements.

2. I/O Response Time

   a. Object scan: All input points connected to DDC system shall update at least every five seconds for use by DDC controllers.

   b. Object command: All devices shall begin to respond to an automatic (generated by software) command of a binary or analog object within 2 seconds.

   c. Operator command: All devices shall begin to respond to a manual (generated by operator) command of a binary or analog object within 5 seconds.
d. Graphics Refresh: The maximum time between an operator's selection of a graphic and it completely painting the screen and updating at least 50 points shall be less than 10 seconds.

3. Alarm Response
   a. The maximum time between a device going into alarm and the annunciation of the alarm shall not exceed 10 seconds for a Level 1 or Level 2 alarm, or 20 seconds for other alarms.
   b. Each workstation on the DDC LAN shall receive alarms within 5 seconds of other workstations.

4. Processing Speed
   a. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every second. Contractor shall be responsible for selecting execution times consistent with the process under control.
   b. Control Loop Performance: Programmable controllers shall be able to execute DDC PID control loops at a selectable frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this frequency.

C. Accuracy and Precision
   1. DDC Contractor shall select sensors, wiring method, transmitters, A/D conversion bits, etc. to provide an end-to-end (fluid to display) sensor accuracy and resolution as specified herein.
      a. DDC sensors shall provide end-to-end accuracy equal to or better than the following:

<table>
<thead>
<tr>
<th>Measured Variable</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Temperature (drybulb)</td>
<td>±1.0°F</td>
</tr>
<tr>
<td>Slab-Embedded Temperature</td>
<td>±0.5°F</td>
</tr>
<tr>
<td>Ducted Air Temperature (drybulb)</td>
<td>±0.5°F</td>
</tr>
<tr>
<td>Mixed Air Temperature (drybulb)</td>
<td>±1.0°F</td>
</tr>
<tr>
<td>Outdoor Air Temperature (drybulb)</td>
<td>±0.5°F</td>
</tr>
<tr>
<td>Outdoor Air Relative Humidity</td>
<td>±3% RH</td>
</tr>
<tr>
<td>Space Relative Humidity</td>
<td>±5% RH</td>
</tr>
<tr>
<td>Air Flow (terminal)</td>
<td>±10% of span*</td>
</tr>
<tr>
<td>Air Flow (measuring stations)</td>
<td>±5% of span</td>
</tr>
<tr>
<td>Air Flow (pressurized spaces)</td>
<td>±5% of span</td>
</tr>
<tr>
<td>Air Pressure (ducts)</td>
<td>±0.05 in-wg</td>
</tr>
<tr>
<td>Air Pressure (space)</td>
<td>±0.01 in-wg</td>
</tr>
<tr>
<td>Carbon Dioxide (CO₂)</td>
<td>±75 PPM</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>±5% of reading</td>
</tr>
<tr>
<td>Chilled and Condenser Water Temperature (at central plant)</td>
<td>±0.2°F</td>
</tr>
<tr>
<td>Chilled and Condenser Water Temperature (general)</td>
<td>±0.5°F</td>
</tr>
<tr>
<td>Hot Water Temperature</td>
<td>±1.0°F</td>
</tr>
<tr>
<td>Water Differential Temperature (at central plant or BTU meter)</td>
<td>±0.25°F</td>
</tr>
<tr>
<td>Water and Gas Flow</td>
<td>±2% of span</td>
</tr>
<tr>
<td>Water Pressure (differential or absolute)</td>
<td>±2% of span</td>
</tr>
<tr>
<td>Non-Utility Power Meters (Amps, Volts, Watts, Power Factor)</td>
<td>±2% of reading</td>
</tr>
</tbody>
</table>

* Applies to 10% - 100% of scale
Note that in many cases accuracy is specified relative to full span (i.e. from minimum to maximum value that will be measured in the application), not full range (i.e. capabilities of sensor). This means that if a sensor’s range is twice what is required for the application (i.e. range is 2 times span) then its accuracy over range must be twice as accurate as specified in this Section.

b. DDC sensors shall provide end-to-end (fluid to display) resolution no worse than half of the specified accuracy.
c. Long-term electronic drift shall not exceed 0.4% per year.

2. Values displayed on graphical screens and recorded in database shall have the following precision:
   a. Values less than 1: three decimal places
   b. Values less than 10: two decimal places
   c. Values between 10 and 999: one decimal place
   d. Values over 1000: integer values only

D. Control Stability
   1. Except as noted in Sequences of Operation, tune all control loops to obtain the fastest stable response without hunting, offset, or overshoot.
   2. Control loops shall maintain each controlled variable at setpoint within the following tolerances:

<table>
<thead>
<tr>
<th>Controlled Variable</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Temperature (drybulb)</td>
<td>±1.5°F</td>
</tr>
<tr>
<td>Ducted Air Temperature (drybulb)</td>
<td>±2.0°F</td>
</tr>
<tr>
<td>Humidity</td>
<td>±5% RH</td>
</tr>
<tr>
<td>Duct Air Pressure</td>
<td>±0.1 in-wg</td>
</tr>
<tr>
<td>Building or Relief Plenum Air Pressure</td>
<td>±0.01 in-wg</td>
</tr>
<tr>
<td>Air Flow</td>
<td>±10%</td>
</tr>
<tr>
<td>Air Flow (pressurized spaces)</td>
<td>±5%</td>
</tr>
<tr>
<td>Chilled Water Temperature</td>
<td>±1.0°F</td>
</tr>
<tr>
<td>Condenser Water Temperature</td>
<td>±2.0°F</td>
</tr>
<tr>
<td>Hot Water Temperature</td>
<td>±3.0°F</td>
</tr>
<tr>
<td>Water Flow</td>
<td>±10%</td>
</tr>
<tr>
<td>Water Differential Pressure</td>
<td>±1.5 PSI</td>
</tr>
<tr>
<td>Other</td>
<td>±2 x accuracy</td>
</tr>
</tbody>
</table>

   3. Control loop shall return its controlled variable to specified tolerances within 3 minutes of any disturbance (equipment startup excepted).

E. Standalone Operation
   1. System design shall eliminate dependence on any central device for alarm generation and control execution. Each controller shall operate independently, performing its own control, alarm management and trend data collection. See Paragraph 2.8D.
   2. All logic, data and sensor inputs required to perform the specified Sequence of Operation, trending and alarming as outlined in this Specification and the Sequence of Operations shall reside in each individual DDC controller, with the exception of certain global points (see Paragraph 3.10B.3).
   3. Should network communications fail, each controller shall automatically continue to execute local control strategies based on local sensor inputs and last-known or default values for global points.
F. Overrides

1. Values for all points, including real (hardware) points and virtual (software) points used in Sequences of Operations (Section 25 90 00) shall be capable of being overridden by the user with appropriate access level.
   a. If DDC System is unable to provide this functionality for hardware points, each hardware point shall be equated to a software point and the software point shall be used in all sequences.

2. Operator overrides shall remain in effect until they expire (timed overrides) or are released/cancelled (indefinite overrides). The DDC System shall not reset active overrides during a data scan/update.

3. The graphical user’s interface shall be designed to make it obvious when a point has been overridden. See Paragraph 3.7A.7.

G. Command Priority

1. The system shall observe the BACnet command priorities, including the following (from highest to lowest):
   a. Life Safety (Priority Level 1 & 2).
   b. Manual Operator Command (Priority Level 5 or 8).
   c. Energy Management (Priority Level 9).
   d. Normal Automatic Control (Priority Level 10 or greater).

2. Operator overrides shall have a higher command priority than automatic/programmed commands generated by the Sequence of Operations.

3. The Superuser (see Paragraph 3.6C.1) shall have a higher (i.e. more dominant) command priority than other users.

H. Alarms and Events

1. The system shall support a minimum of 50 configurable event notification categories. The user shall be able to assign any event or alarm to one or more category.

2. All events shall be generated at the control module level and shall record time and date from the originating local control module.

3. Alarm properties shall be defined using BACnet Event templates, including all the following information:
   a. Name
   b. Verbose description
   c. Alarm level
   d. Whether acknowledgement is required
   e. Whether alarm can clear automatically (i.e. whether acknowledgement of return to normal operation required)
   f. Event reporting action

4. Event Reporting Actions shall be configurable to automatically respond to any individual alarm/event or any alarm/event category. At least the following actions shall be supported:
   a. Display a message (the event message or another predefined message, including images) in a pop-up window at the graphical interface
   b. Save/export message to a text file
   c. Run an external program or routine
   d. Write property to any BACnet device, allowing alarm to change equipment operating mode
   e. Generate an audible annunciation at the operator’s workstation
   f. Notify operators by email, SMS/text-message, or pager
5. System shall support custom lists of individuals to be notified for any individual alarm/event or any alarm/event category.

I. Protection of Products
   1. Enclosures: Control products shall be protected with integral or secondary enclosures as described in Article 2.13.
      a. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions at installed location.
      b. Active environmental control of enclosures is only acceptable under certain conditions. See Paragraph 2.14C.
   2. Surge Protection: Protect all control products connected to AC power circuits from power line surges to comply with requirements of IEEE C62.41. See Paragraph 2.15F.
   3. Power Conditioning: Protect susceptible control products connected to AC circuits from power irregularities and noise. See Paragraph 2.15G.
   4. Ground Fault: Protect all control products from ground faults and ground loops by providing suitable grounding. Products shall not fail due to ground fault condition.

J. Backup Power or UPS
   1. HVAC systems and equipment served by a backup power source or UPS shall have associated DDC system products that control such systems and equipment also served from a backup power source or UPS. See also Paragraph 3.13C.
   2. The Data Archive Server, if provided, shall have a UPS. See Article 2.6.
   3. See Paragraph 2.15D for UPS device requirements.
   4. Additional DDC System components that shall be an emergency power circuit shall include the following:
      a. None required
   5. Additional DDC System components that shall be provided with uninterruptible power shall include the following:
      a. None required

K. Continuity of Operation after Electric Power Interruption
   1. Upon availability of backup power or return to normal power conditions, equipment and associated controls shall automatically return to the operating state occurring immediately before loss of normal power, without need for operator intervention.
   2. Equipment startup shall be automatically staggered to avoid creating demand spikes, per Paragraph 2.8S.4.

2.3 SYSTEM ARCHITECTURE

A. General
   1. The system shall be configured as a distributed processing internetwork capable of expansion as specified herein.
   2. All control products provided for this Project shall comprise an interoperable Native BACnet System. All control products provided for this Project shall conform to ASHRAE Standard 135.
   3. Provide hardware and software resources sufficient to meet the functional requirements specified in this Section. Include all items not specifically described in this Section that are necessary to implement, maintain, and operate the system in compliance with the functional intent of this Specification.
B. Networking Requirements

1. The DDC internetwork shall be open and non-proprietary, and available to other companies for use in making future modifications to DDC system.

2. The ASHRAE 135 BACnet communication protocol shall be sole and native networking protocol used throughout entire DDC system. Only native BACnet control devices shall be used without explicit written permission by the Engineer of Record.

3. Communication gateways, bridges, protocol translators or any other device that translates any proprietary communication protocol to BACnet are not acceptable as a part of the Work under this Section, with specific exceptions. See Paragraph 2.7E.

4. DDC System shall communicate via a dedicated control internetwork that is not shared with other building systems or tenant data and communication networks.
   a. The Owner’s IT network shall not be used for control purposes.
      1) Exception: Supervisory Network may utilize existing Wide Area Network (WAN) if DDC System spans multiple buildings, with permission of Owner.
   b. If permitted by Owners, control internetwork may share router hardware and physical network infrastructure if there is sufficient capacity. Control internetwork must be logically separated from IT network (e.g. by vLAN).
   c. Any use of Owner’s IT infrastructure requires written permission from Owner. DDC Contractor shall coordinate with Owner and Owner’s IT staff.

5. DDC System as provided under this Section shall implement the following BACnet data links only:
   a. BACnet/IP
   b. BACnet Master-Slave/Token-Passing (MS/TP)
      1) MS/TP network backbone speeds shall be 76,800 bps if possible, and no less than 38,400 bps in any case.
      2) Speeds of 9,600 bps or 19,200 bps shall be permitted to connect with specific devices that cannot support higher speeds.
      3) No other speeds shall be acceptable.
   c. Point-to-Point (PTP), for dial-up access, only if required.
   d. BACnet Ethernet (ISO 8802.3).
   e. All other BACnet data links shall be excluded from this Project. Other non-BACnet data links and protocols such as TCP/IP, SMTP, and HTTP, are permitted as required elsewhere in this Section.

6. MS/TP networks are limited as follows:
   a. No single MS/TP network shall exceed a wire run length of 2,000 feet.
   b. Repeaters/amplifiers shall not be used.
   c. Only MS/TP Master devices are permitted. MS/TP slave devices shall not be used.
   d. No single MS/TP network shall exceed 32 full-load nodes.
      1) For the purposes of this Specification, any devices that do not support both the Read Property Multiple (RPM) service and Data Segmentation for both Transmit and Receive, shall be considered full-load nodes.
   e. No single MS/TP network shall exceed 64 devices total, regardless of load level.

7. Irrespective of other network connectivity requirements or lack thereof, the DDC System shall be configured such that devices supporting SMTP can send (but not receive) email over the public internet. This capability shall be used to notify operators of events and alarms as detailed elsewhere in this Section.
8. Wireless communication in any control LAN is not acceptable without review and approval by the Engineer of Record. DDC Contractors who wish to use wireless devices or networking are strongly encouraged to use the pre-submittal process (see Paragraph 1.8F.1).

C. Network Architecture: The DDC network shall consist of no more than three levels of networks.

1. A Supervisory Control Network may be used to connect building controllers, servers and operator workstations.
   a. Supervisory Network may be a Local Area Network, or it may span multiple buildings or locations as a Wide Area Network (WAN).
   b. Supervisory Network link layer shall be Ethernet (IEEE802.3).
   c. Supervisory Network networking layer shall be BACnet/IP and shall share a common network number for the Ethernet backbone, as defined in ASHRAE Standard 135.
   d. Supervisory Network, including all routers and switches, shall support no less than 100 Mbps.
   e. Powerline communications is not acceptable.

2. A Primary Control LAN shall connect advanced application controllers to building controllers and to other advanced application controllers. The Primary LAN communicates exclusively control information.
   a. Each Primary LAN shall be contained within a single building. A single Primary LAN shall not span multiple buildings.
   b. Primary LAN link layer shall be Ethernet (IEEE802.3) or MS/TP.
   c. Primary LAN networking layer shall be BACnet/IP, BACnetEthernet, or MS/TP as defined in ASHRAE Standard 135.
   d. If a Primary LAN communications trunk is severed, the network shall reconfigure itself into separate LANs and continue operations without interruption or requiring operator intervention.
   e. Primary LAN, including all routers and switches, shall support no less than 100 Mbps.
   f. Powerline communications is not acceptable.

3. Secondary Control LANs shall connect application specific controllers to other application specific controllers and to terminal control devices such as networked thermostats. Each Secondary Control LAN shall connect to a Primary Control LAN via a BACnet router, or via an advanced application controller or building controller.
   b. Secondary LAN link layer shall be Ethernet (IEEE802.3) or MS/TP.
   c. Secondary LAN networking layer shall be BACnet/IP or BACnet MS/TP as defined in ASHRAE Standard 135.
   d. Secondary LAN speed and bandwidth shall be dictated by the number of controllers on the LAN, response time and trending requirements, but shall be no less than 38.4 kbps (BACnet MS/TP) or 10 Mbps (BACnet/IP).

4. The network architecture, and number and type of LANs shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all DDC System networks.

5. To the extent feasible, Secondary Control LANs shall be configured so that the control network architecture parallels the mechanical system architecture. For example, a Secondary LAN of VAV controllers should connect directly to the advanced application controller or building controller which controls the air handler that serves the VAV boxes.
D. System Software

1. DDC System Software shall include a BTL-listed BACnet Advanced Workstation (B-AWS) that supports full-featured supervision, configuration, programming and control of the DDC System. See Paragraph 2.4C.
   a. DDC Contractor shall configure laptops, desktops and servers running B-AWS software to connect to the control internetwork. Portable devices running B-AWS shall be able to connect at any Ethernet port on the control internetwork.

2. DDC System Software shall include an Operator’s Web Interface (OWI) that supports complete supervisory access to DDC system and limited control functions via a web browser, without additional software requirements. See Paragraph 2.4B.

3. DDC System Software may include applications to store, manage, retrieve and/or analyze long-term trend data, if required in Article 2.4.

4. All actions shall be able to be performed over the DDC System internetwork. Systems that require direct connection to DDC field devices or controllers for any of these services are not acceptable.

5. All System Software shall be provided and licensed to the Owner per Paragraphs 1.2B.2 and 1.10B.

E. Servers and Operator’s Interface Devices

1. Provide interface device hardware for operators as detailed in Article 2.5.

2. Provide a Data Archive Server if required in Article 2.6.

F. Operator Means of Access

1. DDC Contractor shall configure hardware and software to support the following means of access to the DDC System:
   a. Desktop or portable computer running B-AWS software via hardwired connection to control internetwork or any controller
   b. Portable computer using B-AWS for remote access via hardwired or wireless internet connection and Owner’s VPN tunnel, if required in Paragraph 2.4C.11
   c. Any supported browser using OWI through hardwired connection to control internetwork.
   d. Any supported browser using OWI for remote access via hardwired or wireless connection to Owner’s IT network, and/or via internet connection and Owner’s VPN tunnel if required in Paragraph 2.4B.10.
   e. Portable Operator’s Terminal (POT) via hardwired connection to control internetwork or any controller. Required only if POT is provided per Paragraph 2.5C.
   f. Mobile computing device ("smart" phones, tablets, etc.) using app supplied by DDC System manufacturer or DDC Contractor, via wireless connection to control internetwork. Required only if such an app is available and is desired by Owner.

2. Access to DDC System, regardless of operator means used, shall be transparent to operator.

3. Provide network ports for hardwired connection to controls internetwork. Connect to Supervisory Network if installed, or to Primary LAN if Supervisory Network is not included in Project. Network ports shall be easily accessible, properly protected, clearly labeled (see Article 3.16), and installed at the following locations as applicable to the Project:
   a. Each mechanical equipment room.
   b. Each boiler room.
   c. Each chiller room or outdoor chiller yard.
   d. Each cooling tower location.
   e. Each different roof level with roof-mounted air-handling units or rooftop units.
4. DDC System shall be able to accommodate at minimum five simultaneous operators that are accessing DDC system through any of the means indicated, without impacting performance.

G. Future Expandability

1. System architecture shall be modular. DDC System shall be able to be expanded to an ultimate capacity of at least twice the initial capacity with no impact on performance.
2. Initial network infrastructure shall be designed and installed to support ultimate capacity.
3. Additional DDC controllers and associated wiring shall be all that is needed to achieve ultimate capacity.
4. All controllers (VAV controllers and Application Specific Controls excepted) shall be provided with at least 20% spare point capacity. See Paragraphs 2.9C, 2.10C and 2.11C.
5. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.
6. System architecture shall allow modifications without having to remove and replace existing network equipment.
7. Where any licensing is required, provide sufficient licenses for expansion to ultimate capacity (as above, NOT unlimited capacity) for a minimum of 5 years from start of DDC System warranty.

H. Special Network Architecture Requirements

1. Variable speed equipment: For any equipment such as pumps or fans which use variable speed control to maintain a measured value at a setpoint (e.g. duct static pressure or end of loop differential pressure), the following requirements apply in order to avoid poor control due to network lag or latency, and to maintain stand-alone operational capability in the event of a network failure.
   a. The control loop that calculates the speed command that is sent to the equipment shall be maintained in a DDC controller. Using the VFD’s onboard logic for this purpose is not acceptable, unless explicitly shown that way in Contract Drawing control schematics.
   b. The sensor(s) used for control shall be hardwired directly to the controller which calculates the speed command. Passing the sensor measurement through the network, or hardwiring to a different controller, is not acceptable.
   c. The controller which calculates the speed command shall be hardwired directly to the equipment which receives the speed command. Passing the speed command signal through the network is not acceptable.

2. Gateways: Where gateways are used, some points which are critical to proper operation shall be hardwired to the BAS, as indicated in the Contract Drawing control schematics. These points shall be hardwired even when they are available through the gateway.

2.4 SYSTEM SOFTWARE FUNCTIONS

A. General

1. The DDC System shall be provided with software and/or firmware which performs the functions described in this Article.
2. All System Software functions shall be hosted on one or more of the following platforms. Different functions may be hosted on different platforms, as dictated by system design and control products selection.
   a. Running as application software on the Data Archive Server, if one is present or provided
   b. Embedded in a BACnet Building Controller (B-BC)
c. Embedded in a BACnet control device dedicated to the purpose

3. The device(s) hosting the System Software shall reside on the Supervisory Network if one is present or provided, or on the Primary Control LAN otherwise. Communication shall be BACnet/IP.

4. Devices hosting System Software shall be always on and always connected to the control internetwork.
   a. Exception: This is not required for portable computers hosting the Advanced Workstation (B-AWS) interface.

5. All System Software functions shall be provided by native BACnet applications or devices. In each case, the BACnet operating stack must be embedded in the application core.

6. Security shall be multilayered, supporting at least five access levels with unique credentials for each user. See Paragraph 3.6C.

7. User Interface
   a. Each operator’s interface shall be a full-color graphical user interface (GUI) that supports multiple simultaneous information windows on a single screen.
   b. All interfaces shall be dynamic with displayed data automatically updated from the BACnet internetwork without user intervention or command.
   c. Operator shall be able to easily and intuitively navigate between graphic displays.
      1) Page elements shall be hyperlinked such that clicking on an element will “drill down” to the next level of detail.
      2) Every page shall have a “back” button to return to the previous level and a “home” button to return to the top level.
      3) Use colors in a consistent, logical and intuitive way. For example, indicate normal status with green and alarm status with red.
      4) See also Article 3.6J.
   d. Operator shall be able to individually change the size and location of on screen windows.
   e. The windowing environment shall allow the user to display and interact with several different views simultaneously.
      1) Example: Operator shall be able to compare the performance and operating characteristics of two systems side-by-side.
      2) Example: Operator shall be able to display and acknowledge alarm information without interrupting other work in progress.
      3) This functionality may be provided by support of multiple separate browser windows (for web-based interfaces) or by support of multiple window views within a single application.
   f. All interface elements and windows shall be legible and useable at any display resolution XGA (1024 x 768 pixels) or higher.
      1) Using a higher-resolution screen shall not result in text that is too small to read, or control elements that are too small to select accurately.
      2) Using a screen with a different aspect ratio shall not create distortion of windows, images or graphics.
   g. To the extent practical, all interfaces and windows shall use a common color scheme and common set of symbols and graphics. See also Article 3.6J.

8. Search Function: Provide a search capability that will search all Sequences of Operations for a given point name to determine all sequences that use or control the point.
9. Online Help: Provide a hypertext-based help system to assist the user in operation and modification of the system. Help shall be available for all system applications and shall be context-sensitive to provide information that is relevant to the active window or screen.

B. Operator’s Web Interface (OWI)

1. The Operator’s Web Interface (OWI) provides day-to-day monitoring and basic operation of the DDC System and BACnet internetworks through a web browser interface.
   a. The OWI shall provide the functions required for a BACnet Operator’s Workstation (B-OWS). The OWI shall be listed as a B-OWS or B-AWS by BACnet Testing Laboratories (BTL). Alternatively, non-listed software may be provided for this function but in that case DDC Contractor assumes all responsibility for compatibility, communication, or interoperability issues related to OWI software.
      1) The OWI shall allow the operator to access graphics, point displays, and trends, to create exception schedules, and to perform overrides of variables or points displayed on the control graphics.
      2) The OWI is not required to provide for configuration or programming of the DDC System.
   b. The OWI shall be based on server/thin-client architecture, designed around open standards of Web technology and HTML 5 graphics, which provides operators with complete supervisory access to the DDC System via a web browser. No Java plugins, ActiveX components, or any special software other than a web browser shall be required to access the full functionality described in this Paragraph. The current versions of the following standard web browsers shall be supported at a minimum:
      1) Apple Safari
      2) Google Chrome
      3) Microsoft Edge
      4) Microsoft Internet Explorer
      5) Mozilla Firefox

2. The OWI shall meet all requirements of Paragraph 2.4A in addition to the requirements described in this Paragraph.

3. The OWI shall support at a minimum the BACnet Interoperability Building Blocks (BIBBs) required for B-OWS.

4. User Interface
   a. With the proper credentials the operator shall be able to manually adjust all data point values (hardware or software) in the system, alter or lock control loop output values, set schedules, and command points to manual override, timed override and automatic mode.
   b. All graphical interface objects including animations shall be stored in the DDC System. Applications shall not require system graphics to be pre-loaded on the client browser.
   c. Operators shall have the ability to dynamically create messages associated with individual objects in any information window/view or associated to the window/view itself. These messages are persistent until erased and may be viewed and modified by other operators during other sessions.

5. Alarm/Event Processing
   a. The OWI shall display and log events from any BACnet object in the system and shall support operator configuration of alarm limits, differentials, states and reactions.
      1) The operator shall be able to view all current and past alarms/events from any location in the internetwork.
2) With the proper credentials, an operator shall be able to acknowledge and clear alarms.
3) Alarm log shall satisfy requirements of Paragraph 3.7L.3.

b. Also see Paragraph 2.2H for alarm/event capabilities.

6. Scheduling
   a. The interface shall support viewing existing schedules per Paragraph 3.7K.
   b. A properly-credentialed operator shall be able to create exception schedules from the daily, weekly, or monthly views.

7. Trend Logs
   a. OWI shall support the viewing and manipulation of trend data. Trend log creation/setup is not a required feature for the OWI.
   b. The interface shall be able to display trend data as timeseries graphs (i.e. two-axis (x, y) graphs that simultaneously display values relative to time).
      1) Graph shall be able to display at least eight objects in different colors, even if objects have been trended at different time intervals.
      2) Where trended values are COV, software shall automatically fill the trend samples between COV entries.
      3) A graph legend shall identify each variable plotted.
      4) Multiple scales shall be possible, one for each object, with range set automatically by the software but capable of being manually adjusted by the operator.
      5) Data shall be able to dynamically update at operator-defined intervals, including on a 1 second interval for loop tuning.
      6) It shall be possible to zoom-in on a particular section of a trend for more detailed examination and pan through historical data by simply scrolling the mouse.
      7) It shall be possible to pick (or float mouse over) any sample on a trend and have the numerical value displayed.
      8) These capabilities shall be intrinsic to the interface and shall not require the download of data to a separate application.
   c. The operator shall have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard Windows keystrokes.
   d. Trend log data shall be able to be exported as tables in CSV or XLS formats. Interface shall be able to export at least 25 trends to a single file; solutions which require exporting each trend one at a time shall not be accepted.
   e. Graphical representations of trend data log data shall be able to be saved/exported as an image file in a common format (JPG, PNG, GIF, or TIFF).
   f. Trend log data stored on controllers and data stored on the Archive Server (if any) shall be integrated seamlessly, in the same table or graph, without additional effort from the operator.

8. Runtime Logging and Totalization
   a. The system shall provide runtime totalization for every binary object in the system which indicates the operation of equipment.
   b. The operator shall be able to create, view, and reset runtime logs via the interface.
   c. Runtime data shall be stored locally in the BACnet device which holds the binary object, using standard BACnet objects and properties.
   d. Runtime logs shall record total accumulated active time and total accumulated active transitions since last reset. Logs shall also record the timestamp and state for the last 100 transitions on a rolling basis.
1) Runtime data shall be preserved until reset by the operator. It shall not be overwritten, nor shall it be archived.

9. Provide an audit trail feature that automatically records the date, time, user, and action associated with all user access and changes to the DDC System.

10. Remote Access

a. DDC Contractor shall connect the device hosting the OWI to the Owner’s IT LAN or WAN. This connection shall permit any authorized user to access the OWI from any browser on the Owner’s IT network, but shall not permit access from outside the Owner’s network or via the World Wide Web.

b. DDC Contractor shall configure OWI for secure offsite access through a Virtual Private Network (VPN) tunnel.

1) The VPN tunnel and associated hardware and software shall be the responsibility of Owner’s IT staff.

2) VPN tunnel shall use login credentials established and maintained by Owner’s IT staff. These credentials shall be distinct from the DDC System user/password database described in Paragraph 3.6C.

3) Under no circumstances shall the B-OWI be accessible via the World Wide Web or over the public internet through means other than the VPN tunnel.

c. DDC Contractor shall coordinate with Owner’s IT department.

d. The OWI host device shall be configured to be always connected. See Paragraph 2.4A.4.

e. All communication on the IT LAN/WAN or the Internet shall utilize Secure Socket Layer (SSL) or Transport Layer Security (TLS) technology.

f. Proper credentials shall be required in order to log into OWI regardless of means of connection.

C. BACnet Advanced Workstation (B-AWS)

1. The BACnet Advanced Workstation (B-AWS) provides for the complete configuration, monitoring, modification, programming and operation of the entire DDC System.

2. The Advanced Workstation shall:

a. Comply with the minimum requirements of ASHRAE Standard 135 Annex L for a B-AWS and shall be certified and listed by the BACnet Testing Laboratories (BTL) as a B-AWS prior to the bid date for this Project.

b. Meet all requirements and provide all functions in Paragraph 2.4A.

c. Meet all the requirements and provide all functions in Paragraph 2.4B, except as follows:

1) The B-AWS may be a client-based application is not required to follow the thin client model or support access via web browser as described in Paragraph 2.4B.1.b.

2) The remote access provisions and connections described in Paragraph 2.4B.10 do not apply to the B-AWS. See Paragraph 2.4C.11 instead.

d. Meet all requirements and provide all functions described in this Paragraph (2.4C).

3. DDC System Configuration and Programming Capabilities

a. The B-AWS shall provide a complete engineering tool for the configuration of the system, allowing a properly-credentialed user to create, delete or modify any configuration parameter, program, graphic, trend log, alarm, schedule or BACnet object in the DDC System.

b. The B-AWS shall provide a complete programming environment for the creation and modification of control logic algorithms using graphics (wire sheet), text (line code) or some combination.
c. Provide a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of Sequences of Operations. Include at least the following:

1) Proportional (P-only), proportional-integral (PI), and proportional-integral-derivative (PID) control loops.
2) Software tools for tuning control loops and adjusting gains.
3) Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time-of-day, high-signal select, low-signal select.
4) Standard logic operators such as AND, OR, NOT, and XOR (exclusive OR).
5) Operators for basic arithmetic
6) Relational operators such as is-equal, not-equal, greater-than and less-than
7) Operators for square root, raise to a power (i.e. \( x^y \)), log, natural log, absolute value, and minimum/maximum value from a list
8) Basic trigonometric operators such as sine, cosine, and tangent
9) Psychrometric parameters: calculation of wetbulb, dewpoint, and enthalpy from drybulb temperature and relative humidity.

d. Include a search capability that will search all control sequences for a given point name to determine all sequences that use or control the point.

4. Groups
   a. The user shall be able to assign BACnet objects, parameters or points to groups manually, by type, or using wildcard search.
   b. A properly-credentialed user shall be able to apply batch modifications or overrides to an entire group with a single action.
   c. A single object or point may belong to more than one group. If multiple overrides conflict on a single object, the one with the highest assigned priority shall prevail.
   d. See Paragraph 3.6F.2 for initial configuration of groups.

5. Security
   a. Authorized users (see Paragraph 3.6C.1) shall have the ability to configure credentials for all other operators.

6. User Interface
   a. In addition to the other override capabilities described above, a user with proper credentials shall be able to
      1) Manually adjust control loop tuning parameters (gains) and employ loop tuning tools.
      2) Apply overrides (manual, timed, or return to automatic operation) to all members of a defined group of BACnet objects (see Paragraph 2.4C.4).
      3) View a list or generate a report of all points and objects currently in override.
      4) Globally release (i.e. return to automatic operation) all overridden points and objects.
      5) View and modify the status and present value of any BACnet object or property in the DDC System, including all real and virtual input and output points.
   b. A properly-credentialed user shall be able to create, edit, install and remove control programming from any device on the DDC system.
   c. A properly-credentialed user shall be able to
      1) Create new and edit existing graphical pages, views and displays, including read-only web pages served by the OWI (if applicable).
      2) Link graphical interface pages to DDC points, objects and control logic to create new dynamic control interfaces which are available through the OWI.
a) Graphic images may reside anywhere on the DDC System; however, all dynamic data and attributes must reside in its associated controller or device.

d. B-AWS software shall support at a minimum BMP, GIF, TIF, JPG, EMF, PNG, SWF and DIB graphic file formats and allow for the use of custom animation objects and URL hyperlinks.

e. See also Paragraph 3.6J

7. Scheduling

a. The B-AWS shall allow properly-credentialed users to create, delete, modify and view binary, analog and multistate BACnet Schedule objects and parameters.

b. All capabilities of the interface described in Paragraph 3.7K shall be available.

8. Trend Logs

a. The B-AWS shall support creation of custom trends for any object in the system.

   1) Trends shall be created using the BACnet Trend Log and BACnet Trend Log Multiple objects.

   2) Trends may be created with any sampling frequency or Change of Value (COV) threshold.

   3) Trends may be active indefinitely, or defined with specific start and end times.

b. Trend data shall be sampled and initially stored locally in the BACnet device which holds the object being trended. No additional server or device shall be required for collection or short-term storage of trend data.

c. All trend log display, visualization and export functions supported by the Operator’s Web Interface shall also be available through B-AWS. See Paragraph 2.4B.7.

9. System Diagnostics: Provide fully automatic verification of internetwork communication with automatic alarming in the event of communications failure.

10. DDC System Configuration/Programming Backup and Restore

a. The B-AWS shall allow a properly-credentialed user to backup, restore and/or clear configuration data and control programming from any device on the DDC System internetwork.

b. The B-AWS shall be able to perform automated network backup of configuration, control programming and graphics in all devices on the DDC System internetwork according to operator configurable schedule and storage directory structure.

c. If Data Archive Server is provided, the DDC Contractor shall configure automatic backup of the DDC System configuration, programming and graphics once per week or as requested by building maintenance staff. Configure system to retain at least last four backups.

11. Remote Access by VPN Tunnel

a. DDC Contractor shall configure DDC System to support the following means of secure offsite access to B AWS via a Virtual Private Network (VPN) tunnel.

   1) Remote Desktop: Using Microsoft Remote Desktop or equivalent software, configure to allow access to B-AWS running on Data Archive Server from any machine with the appropriate VPN client and credentials installed.

   2) Portable Workstation: Coordinate with Owner’s IT staff to configure laptop running B-AWS software (see Paragraph 2.5B) to connect to DDC System remotely via VPN tunnel. Full B-AWS functionality shall be available through this connection.

b. The VPN tunnel and associated hardware and software shall be the responsibility of the Owner’s IT.

c. DDC Contractor shall coordinate with Owner’s IT department.
d. VPN tunnel shall use login credentials established and maintained by Owner’s IT. These credentials shall be distinct from the DDC System user/password database described in Paragraph 3.6C.
e. Under no circumstances shall the B-AWS be accessible via the World Wide Web or over the public internet through means other than the VPN tunnel.

D. BACnet Trend Archive Software

1. Trend Archive software shall acquire trend log data from networked control devices and archive it for long-term storage in a BQL or SQL database. This does not supersede the requirement for local short-term storage of trend and runtime data on individual BACnet devices.

2. Trend Archive software may be installed on the Data Archive Server or may be embedded in a control device.

3. Trend Archive software shall reside on the Supervisory Control Network or the Primary Control LAN, and shall communicate via a BACnet/IP data link.

4. Connection to multiple BACnet/IP network segments and BACnet internetworks shall be supported with a single installation instance.

5. Trend Archive software shall be capable at a minimum of performing the following tasks automatically without user intervention:
   a. Manage the connection to the internetwork based upon configurable data acquisition thresholds, retrieving data only when necessary rather than streaming data.
   b. Retrieve data from all BACnet Trend Log and BACnet Trend Log Multiple objects from any BACnet device on the internetwork.
   c. Store acquired data in a standard BQL/SQL database, accessible by third-party applications.
   d. If temporarily unable to access the database, build a storage queue of data to be written to the database when it becomes available.

6. Continuous streaming of trend data consumes excessive network bandwidth and is not acceptable.

7. Trend Archive software shall support at a minimum the following BACnet Interoperability Building Blocks (BIBBs):
   a. Data Sharing-ReadProperty-A (DS-RP-A)
   b. Data Sharing-ReadProperty-B (DS-RP-B)
   c. Data Sharing-ReadPropertyMultiple-A (DS-RPM-A)
   d. Data Sharing-ReadPropertyMultiple-B (DS-RPM-B)
   e. Data Sharing-WriteProperty-A (DS-WP-A)
   f. Trending-Automated Trend Retrieval-A (T-ATR-A)
   g. Trending-Automated Multiple Value Retrieval-A (T-AMVR-A)
   h. Trending-Archival-A (T-A-A)
   i. Device Management-Dynamic Device Binding-A (DM-DDB-A)
   j. Device Management-Dynamic Device Binding-B (DM-DDB-B)
   k. Device Management-Dynamic Object Binding-B (DM-DOB-B)

8. Trend Archive software shall not limit the size of the database file. Quantity of archived data shall be limited only by the SQL license or the available hard drive space.

E. Database Management Software

1. Provide standards-compliant BQL or SQL relational database for long term storage of trend data.

2. Database shall be fully compatible with other DDC System software, such as the BACnet Trend Archive application.
3. Database shall support Java Database Connectivity (JDBC) and Open Database Connectivity (ODBC) or shall include the necessary drivers and software bridges to enable real-time access of data via XML/SOAP.
4. Database file(s) shall reside on the Data drive, not the Boot drive.
5. Database shall support reading and writing of data while running. Data retrieval shall not impact or interrupt retrieval and storage of data from networked control devices.
6. Some database implementations, notably Microsoft SQL Server Express, limit the allowable size of the database file. DDC Contractor shall either provide a SQL implementation that does not impose an inherent limit on database file size OR shall provide work-arounds for this limit as described in Paragraph 3.6B.5.b.
7. Database management software shall regularly perform automatic data integrity checks.
8. Configure database so that, in the event that it runs out of space, oldest data is overwritten by newest data so that the longest possible continuous data record is maintained. **Ceasing to record trend data due to lack of space is not acceptable.**
9. Manufacturers: Microsoft SQL Server Express (free, but limited), Microsoft SQL Server, MySQL/MariaDB, PostgreSQL (free), SQLite, or equal

F. Trend Analysis and Reporting Software
   1. Not required.

2.5 HARDWARE DEVICES FOR OPERATOR’S INTERFACE

A. Operator’s Desktop Workstation
   1. Data Archive Server, if provided, shall act as operator’s desktop workstation. See Article 2.6. If no Data Archive Server is specified, then an operator’s desktop workstation is not required.

B. Operator’s Portable Workstation
   1. Operator’s portable workstation shall be a laptop computer (not tablet) with the following minimum specs
      a. Certifications
         1) Energy Star
         2) EPEAT Silver or better
      b. CPU: minimum dual-core, 1GHz, 64-bit
      c. RAM: 8 GB minimum, expandable to 16 GB
      d. Hard Drive (boot and data drive) for operating system and all software
         1) SATA 3.0 (6 MB/s)
         2) Solid state (SSD)
         3) 128 GB minimum
      e. Optical Drive: not required
      f. Network Interfaces:
         1) Wired: 1000 base-T Ethernet with RJ45 connector port
         2) Wireless: 802.11g/n/ac network adapter
      g. I/O Ports, minimum:
         1) Two USB 2.0 ports
         2) One USB 3.0 port
         3) One microphone/line-in and one headphone/stereo-out connector
         4) One HDMI or DisplayPort output
h. Display:
   1) Built-in, not detachable
   2) Flat panel LCD with LED backlight
   3) 14” minimum size
   4) 1024x768 or better native resolution
   5) Screen must be able to maintain its position relative to keyboard without a table or additional support, to facilitate use with one hand while holding device with the other. (Some modern convertible units, like the Microsoft Surface, cannot do this.)

i. Keyboard: Built-in

j. Touchpad: Built-in

k. External Mouse:
   1) Three button mouse with scrollwheel
   2) Wireless USB or Bluetooth

l. Operating System: Windows 10 Professional, 64-bit

m. Installed Software:
   1) Browsers (install all three)
      a) Microsoft Internet Explorer or Microsoft Edge
      b) Firefox
      c) Google Chrome
   2) Office suite: LibreOffice (free), Apache OpenOffice (free), or Microsoft Office
   3) PDF reader: Adobe Acrobat Reader or equal
   4) BACnet Advanced Operator Workstation (B-AWS) software per Paragraph 2.4C.
   5) Simulation tools, if required per Paragraph Error! Reference source not found.
   6) Trend Analysis Software if required per Paragraph 2.4F.

2. Provide one device.

3. Device shall be purchased as a complete system from a single major manufacturer (e.g. Dell, HP, etc.) with manufacturer warranty, as a current product offering. Discontinued, refurbished, or used hardware is not acceptable.

4. Provide padded carry bag with shoulder strap. Laptop must fit snugly without excessive movement.

C. Portable Operator's Terminal (POT)

1. If DDC System manufacturer produces a POT for the product line being installed, DDC Contractor shall provide 1 POT unit included in Project cost. If no POT is available from the manufacturer, none are required.

2. POT shall include a network cable and jack for connection to DDC controllers, network ports or instruments with an integral network port.

3. POT shall be powered through network connection.

4. Connection of POT to DDC system shall not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or preclude central initiated commands and system modification.

5. POT shall give operator the ability to do the following:
   a. Display and monitor the value of any analog, binary or virtual output point.
   b. Display or override the value of any analog, binary or virtual input point.
   c. Display and monitor I/O point in alarm.
   d. Add a new or delete an existing I/O point.
   e. Enable and disable I/O points, initiators, and programs.
Display and change time and date.
Display and change schedules.
Display or reset run-time counters and run-time limits.
Display and change control application and DDC parameters.
Display and change programmable offset values.
Access DDC controller initialization routines and diagnostics.

D. Mobile Computing Device
1. Mobile computing devices ("smart" phones, tablets, etc.) will be provided by Owner if required.
2. DDC Contractor shall install and configure manufacturer-produced iOS or Android "apps" designed for use with DDC system, if available from the manufacturer.
3. Install and configure apps on all compatible devices provided by Owner.
4. Provide Owner with unlimited license, including perpetual free updates, for all apps.
5. For at least the duration of the Warranty Period, allow Owner to install apps on additional devices without requiring DDC Contractor involvement and at no additional cost.

2.6 DATA ARCHIVE SERVER

A. General
1. General
   a. Data Archive Server performs the following functions:
   b. Provide robust storage of DDC System configuration and programming
   c. Provide a database for long-term storage of trend data
   d. Host the BACnet Trend Archive Software
   e. Host for the Advanced Workstation (B-AWS) software
2. Include boot drive (Hard Drive #1) capacity sufficient for operating system, applications which perform specified System Software Functions (see Article 2.4), and additional software applications as specified below.
3. Include data drive (Hard Drive #2) capacity sufficient
   a. To archive complete copies of all DDC programming and associated data, including DDC controller programs and databases. This archive shall be sufficient to completely recreate the DDC controller programming and configuration in the event of a total loss of field-level memory and storage.
   b. To store no less than 48 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.

B. Server Rack Configuration
1. Data Archive Server shall be installed in the datacenter/IT room, as indicated on Contract Drawings mechanical floorplans.
2. Provide the following in addition to the requirements of 2.6C.
   a. Case: Rack-mount case, 1U height, suitable for standard EIA 19" rack
   b. Display: none required
   c. Keyboard: none required
   d. Mouse: none required
   e. Optical Drive: none required
3. Configure for on-site access via Microsoft Remote Desktop or equivalent. Coordinate with Owner’s IT. Do not configure to permit access from offsite unless specifically required.
C. Server Hardware

1. Purchased as a complete system from a single major manufacturer (e.g. Dell, HP, Compaq, etc.) with manufacturer warranty, as a current product offering – discontinued, refurbished, or used is not acceptable.

2. Server shall be a desktop computer with the following minimum specs
   a. Certifications
      1) Energy Star
      2) EPEAT Silver or better
   b. CPU: minimum quad-core, 2GHz, 64-bit, latest generation Intel Core i5 or equal
   c. RAM: 16GB minimum, expandable to 32 GB
   d. Hard Drive #1 (Boot drive) for operating system and all application software
      1) SATA 3.0 (6 MB/s)
      2) Solid state (SSD)
      3) 128 GB minimum
   e. Hard Drive #2 (Data drive) for trend database, and for backup of DDC programming and system configuration
      1) SATA 2.0 (3 MB/s) or better
      2) Solid state (SSD) or spinning media (HDD)
      3) Minimum 2 drives of 1TB (i.e. 1000 GB) each, or more if necessary to satisfy requirements outlined in 2.6A.2, configured in RAID 1 (100% redundancy).
         a) Configure to automatically notify operator in the event of failure of either drive in RAID 1 array.
   f. Network Interface:
      1) 1000 base-T Ethernet with RJ45 connector port
      2) Wireless networking is not acceptable
   g. I/O Ports, minimum:
      1) Front panel:
         a) Two USB 2.0 ports
         b) One USB 3.0 port
         c) One microphone and one headphone connector
      2) Back Panel:
         a) Four USB 2.0 ports
         b) Two USB 3.0 ports
         c) One stereo line-in and one stereo output connector
         d) One 9-pin serial port.

3. Backup Drive
   a. Provide external hard drive (HDD) equal or larger in capacity to boot drive, with USB 3.0 connection.
   b. Configure for automatic backup of boot drive per Paragraph 3.8A.4.

4. Uninterruptible Power Supply (UPS)
   a. Per Paragraph 2.15D
   b. Sufficient to power server at full load for five minutes, including display if provided.
   c. Configure to automatically shut down server before UPS is depleted and notify building engineer via email, and automatically restart server when power is restored.
D. Server Software


2. Install software including the following:
   a. Browsers (install all three)
      1) Microsoft Internet Explorer or Microsoft Edge
      2) Firefox
      3) Google Chrome
   b. Office suite: LibreOffice (free), Apache OpenOffice (free) or Microsoft Office
   c. PDF reader: Adobe Acrobat Reader or equal

3. Install software to provide required System Software Functions.
   a. BACnet Advanced Operator Workstation (B-AWS) software per Paragraph 2.4C.
   b. Simulation tools, if required per Paragraph Error! Reference source not found.
   c. BACnet Trend Archive software if required per Paragraph 2.4D.
   d. Database Management software if required per Paragraph 2.4E.
   e. Trend Analysis Software if required per Paragraph 2.4F.

4. Store on Data drive a complete copy of DDC System databases, user screens, graphics, setpoints, settings and all other data necessary to recover from complete loss of system programming. See Paragraph 1.9B.3

2.7 NETWORK COMMUNICATION DEVICES

A. General

1. These shall be microprocessor-based communication devices providing data routing, protocol translation, and/or message transmission on the DDC internetwork as described below.

2. Devices may be independent or may be embedded within a DDC controller.

3. Each independent device (i.e. not embedded within a controller) shall have its own microprocessor, RAM, battery, real-time clock, communication ports, and power supply.

4. Device memory shall be protected in the event of a power failure, per Paragraph 2.8J.1.

B. Supervisory Network Router

1. The Supervisory Router shall act as a router between the Supervisory Network and the Primary LAN.

2. Supervisory Router functions may be performed by a Building Controller, or by a separate device.

C. Controller Local Area Network Interface Device (LANID)

1. Each Controller LANID shall act as a gateway/router between the Primary LAN and a single Secondary LAN, and shall supervise communications on a polling Secondary LAN.

2. Controller LANID functions may be provided by a Building Controller or Advanced Application Controller, or by a separate device.

D. BACnet Broadcast Message Routing

1. Provide a BACnet/IP Broadcast Management Device (BBMD) for each subnet on the internetwork.

2. DDC System shall support the ability for a common BBMD Broadcast Distribution Table (BDT) to be configured once and then sent to all BBMDs.
3. BBMD shall be configured for two-hop distribution. Multicast messaging and one-hop distribution are not acceptable.

4. The DDC Contractor shall provide a spreadsheet documenting the following information, which shall be included with Closeout documents
   a. The identity, physical location and network address of all BBMD in the control system.
   b. The broadcast distribution table for each BBMD.

5. The DDC Contractor shall be responsible for maintenance and configuration of all system BDTs for the duration of the warranty period.

E. BACnet Gateways and Network Devices

1. Contractor shall provide network-connected equipment with a native BACnet interface, if such is available. The use of equipment with a different communications protocol (e.g. Modbus) plus a gateway is not acceptable if equivalent product is available with a native BACnet interface.

2. Resource meters (measuring water consumption, energy use, etc.) which communicate via network interface (as opposed to analog or pulsed binary output) shall support native BACnet communication and shall be considered gateways for purposes of this Section.

3. Communication gateways, bridges, protocol translators or any other device that translates any proprietary communication protocol to BACnet are generally not acceptable. Exceptions are as follows:
   a. Protocol translators as required to communicate to existing building systems or legacy control systems are not prohibited.
   b. Equipment-specific gateways and dedicated controllers are not prohibited provided that both of the following are true:
      1) The device to be controlled is not available with a native BACnet communication interface.
      2) The gateway is supplied, recommended or endorsed by the manufacturer of the equipment it is to control.

4. Each gateway shall be responsible for the interface between the BACnet DDC System and no more than one other piece of equipment. Secondary or parallel control networks utilizing non-BACnet protocols are not acceptable.
   a. Exception: Plant equipment with an integrated controller provided by the manufacturer may directly control associated ancillary equipment (e.g. a chiller’s onboard controller may control its associated pumps) if so depicted on Contract Drawing control schematics.

5. Gateways shall be able to
   a. Read and view all readable object properties from non-BACnet network to BACnet network and vice versa, using standard BACnet services.
   b. Write to all writeable object properties to non-BACnet network from BACnet network and vice versa, using standard BACnet services.

6. Gateways shall support the following BACnet communications services and features at a minimum:
   a. Data Sharing Subscribe Change of Value, Server (DS COV B) (not required for resource meters)
   b. Data Sharing Read Property Multiple, Server (DS RPM B)
   c. Device Management Dynamic Device Binding, Server (DM-DDB-B)
   d. Device Management Dynamic Object Binding, Server (DM-DOB-B)
   e. Device Management Device Communication Control, Server (DM DCC B)
   f. BACnet transmit and receive frame segmentation (not required for resource meters)
g. Post-installation, field-configurable maximum information frames, APDU frame timeout, APDU segment timeout and APDU retries.

7. Point information from any gateway shall be available for use in a control sequence by any other controller, directly through the BACnet internetwork. The use a communications server between control panels and gateways is not acceptable.

8. Gateways may perform only single-pass (i.e. directly to/from BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.

9. Every logical BACnet device represented by a gateway shall have a Device Object instance number assigned which shall be unique throughout the entire internetwork. This includes all physical devices as well as any logical BACnet devices that are physically represented by gateways.

10. Each gateway shall have the capacity to expand the number of BACnet objects of each type supported by 20% to accommodate future system changes.

11. Gateways, and any devices represented by gateways, which have time-of-day information shall synchronize date and time using standard BACnet services.

12. Gateways shall have the ability to collect and archive trend data to the Data Archive Server, if provided.

13. For each gateway, provide an interoperability schedule showing each point or event on legacy side that BACnet network will read, and each parameter that BACnet network will write to.

14. Provide all hardware, software, licenses and configuration tools required for gateway configuration and communication.

15. Provide backup copy of all programming and parameters for all gateways, including interoperability schedule, as part of the Project data archive (see Paragraph 1.9B.3).

16. All gateways shall meet the requirements of UL 916 CE FCC part 15 Subpart B - Class A with surge and transient protection circuitry for power and communications.

F. Wireless Networking and Communications

1. Wireless networking and communications devices shall not be used in the DDC System BACnet control internetwork without specific written permission from the Engineer of Record. No portion of the trunk of the Supervisory Network, Primary LAN or Secondary LAN may rely on a wireless data link.

   a. Exceptions will be considered with adequate documentation and time to review. If DDC Contractor wishes to use wireless devices or wireless communication, a pre submittal per Paragraph 1.8F.1 is required. Do not submit wireless devices for the first time with Submittal Package 1.

2. Wireless networking is permitted on the Supervisory Network or Primary LAN only for the purpose of connecting a portable computer running the BACnet Advanced Workstation, accessing the Operator’s Web Interface, or accessing other System Software functions.

   a. Secure wireless access point with WPA2 and minimum 8-character password.

      1) Do not use passwords that are also used for DDC System login credentials.
      2) Change all default passwords.
      3) Provide password information to Owner per Paragraphs 1.9B.4 and 1.9C.2.

   b. Hardwired connection points to the control internetwork per Paragraph 2.3F.3 are required regardless of availability of wireless connections.

3. If the Operator’s Web Interface is accessible through the Owner’s IT LAN (see Paragraph 2.4B.10), the terminal connection may be made over a wireless link if supported by the Owner’s IT LAN.
2.8 DDC CONTROLLERS

A. General

1. DDC controllers shall perform monitoring, logging and control functions as specified. All specified controller functions shall be resident in the controller.

2. Every DDC controller shall be a tested, certified, and stamped native BACnet device, listed by the BACnet Testing Laboratories (BTL) or submitted by the manufacturer to BTL for listing, prior to the bid date for this Project.
   a. The BACnet operating stack must be embedded directly in each individual device at the media access controller level.
   b. The firmware of every DDC device shall be the same major version as the product that was certified by BTL or has been submitted to BTL pending certification. (In other words, if the device was certified with firmware version 2.0, firmware version 2.1 would be acceptable, but firmware version 3.0 would not. However, if firmware version 3.0 has been submitted to BTL and the certification testing process is ongoing, then it would be acceptable.)

3. DDC controllers shall include a real-time operating system resident in ROM or EEPROM, which shall execute independently from any other device in the system.

4. Controller software shall include a BACnet-compliant command prioritization scheme to allow functional override of control functions. Note that per Paragraph 2.2F, it is a requirement that any point can be overridden by the operators. This is required for all input and output points, and all hardware and software points.

B. Control Loops

1. All DDC controllers shall support at minimum
   a. Two-position (on/off) control
   b. Proportional-only control
   c. Proportional plus integral (PI) control
   d. Proportional-integral-derivative (PID) control

2. Control loop algorithms shall be an intrinsic function, requiring no additional programming or hardware.

3. Both direct- or reverse-acting control loops shall be supported.

4. Control loops shall incorporate anti-windup technology or software.

5. All control loop gains shall be independently adjustable.

6. To avoid excessive wear on modulating actuators, controller shall use anti dithering software or programming to limit the frequency of small re-positioning commands.

7. DDC System shall be provided with loop tuning tools for calculation of proportional, integral, and derivative gains for stable control loop operation. Loop tuning tools provided with the BACnet Advanced Workstation software is acceptable.

C. Programmability: All controllers shall be fully programmable and support custom control strategies, programs and databases that are completely modifiable over the BACnet internetwork once installed.

1. Control systems that exclusively utilize configurable-only ‘canned’ programs or programmable read only memory (PROM) application programming are not acceptable in any controller.

2. All controllers delivered as a part of this Specification shall be programmed using a single common programming language, means and method via the operator’s interface. Devices that require specific custom applications for configuration shall not be acceptable.

3. Control programming shall employ the BACnet protocols for Standard Command Priorities.
4. The controller must be capable of supporting software (virtual) points to be used in Sequences of Operations, monitored and overridden just as if they were real digital or analog points.
5. The user shall be able to add, delete, or modify objects in real time without taking the controller offline or impacting the operation of the controlled equipment.
6. Programming shall provide all the necessary mathematics, logic, utility and control functions necessary to execute the specified sequence of control.

D. Standalone Operation: Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a system wide distributed network. See 1.2C.
   1. Each controller shall contain software to perform full PID loop control.
   2. The complete operational database and application program for the controlled equipment shall reside in each individual controller.
   3. Each individual mechanical system or piece of equipment shall be controlled by no more than one controller with sufficient capacity to be connected to all field devices and sensors associated with that system and/or piece of equipment. See Paragraph 3.10B.1.
   4. DDC devices that require any supervisory server software or hardware or any external platform to manage execution or network management are not acceptable.
   5. Controllers with modular back planes that allow plug-in point modules as an integral part of the controller, and I/O point expander boards plugged directly into the main controller board, are acceptable with respect to a controller's requirement for standalone functionality.

E. Communication
   1. Data shall be shared between networked controllers and other network devices. Point information from any controller (including BCs, AACs, and ASCs) and from any gateway shall be capable of being used in a control sequence in any other panel.
   2. Communication software shall include error detection, correction and re-transmission to ensure data integrity.
   3. Each controller shall be capable of locally executing global strategies for the DDC System based on information from any object in the internetwork. Control systems that require a higher-level host processor for update, time stamps, global point data, COV transfer, online control instruction, or communications control between panels is not acceptable.

F. Input and Output Point Interface
   1. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
   2. Input and output points shall be protected from voltage up to 24 V (AC or DC) of any duration so that contact will not damage controller.
   3. Each output point shall have a programmable signal value which is output in the event of a failure. The controller shall transmit and maintain this failure signal in the event of a system malfunction as long as power is available at the controller. This failure signal shall be determined on a per point basis.
   4. Analog Inputs (AI) points:
      a. AIs shall include monitoring of low-voltage (0-10 VDC or 0-5 VDC), current (4 - 20 mA) and resistance signals from thermistor and RTD sensors.
      b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
      c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution based on the type of controller (specified in subsequent Sections) or as required to comply with specified accuracy requirements.
      d. Signal conditioning including transient rejection shall be provided for each AI.
      e. Each point shall be capable of being individually calibrated for zero and span.
f. Each point shall be a discrete input to the controller board. Multiplexing to a separate manufacturer’s board is unacceptable.

g. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10,000 ohms.

5. Analog Output (AO) points:
   a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution based on the type of controller (specified in subsequent Sections) or as required to comply with specified accuracy requirements.
   b. Output signals shall have a range of 4-20 mA or 0-5 VDC or 0-10 VDC as required for proper control of output device. Pulse-width modulated (PWM) analog signals are not acceptable.
   c. Each point shall be capable of being individually calibrated for zero and span.
   d. AOs shall not exhibit a drift of greater than 0.4% of range per year.

6. Binary Input (BI) points:
   a. Controller BIs shall accept contact closures or pulses and shall ignore transients of less than 5 ms duration.
   b. BIs shall be isolated and protected against an applied steady-state voltage of up to 48VAC peak.
   c. BIs shall include a wetting current of at least 12 mA and shall be protected against effects of contact bounce and noise.
   d. BIs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.
   e. BIs configured for pulse counting shall be capable of counting at least 10 pulses per second. Buffer shall be provided to totalize pulses.
   f. Software multiplexing of an AI and resistors is unacceptable.

7. Binary Output (BO) points:
   a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.
      1) Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1/2 amp at 24VAC or 24VDC.
      2) Triac outputs shall include at least 48V of isolation. Minimum contact rating shall be 1 amp at 24VAC or 24VDC.
   b. Each point shall be configurable as normally open or normally closed.
   c. Each point shall be a discrete output from the controller board. Multiplexing to a separate manufacturer’s board is unacceptable.

8. Universal Input (UI) points:
   a. Shall incorporate all of the features of BI points and AI points.

9. Universal Output (UO) points:
   a. Shall incorporate all of the features of BO points and AO points.

G. Scheduling: All controllers shall support the standard BACnet Schedule and BACnet Calendar objects
   1. Schedule objects shall reside in each individual device. Scheduling that requires an ongoing active connection to a workstation or server shall not be acceptable.
   2. BACnet Schedule objects shall support binary, analog, and multi-state values.
   3. Each calendar day shall support up to a minimum of ten (10) transitions.
4. BACnet Schedule objects shall be able to directly command any BACnet object in the internetwork without requiring custom programming.

H. Time Synchronization

1. Operators shall be able to set the time and date in any device on the network that has a real-time clock.
2. The operator shall be able to set the time and date for an individual device (for override/testing purposes) or for all devices simultaneously.
3. Automatic time synchronization shall be provided using BACnet services.

I. Timed Override

1. All controllers shall support operator-initiated timed overrides of hardware and software objects with user-configurable override periods. When the override period has expired, the controller shall automatically return the object to the automatic state without any additional action on the part of the Operator.
2. The timed override functionality shall exist entirely in the controller. A workstation shall not be required for the execution of the time period nor for returning the object to automatic.

J. Memory: Each controller shall have sufficient memory to support its operating system, database, and programming requirements.

1. Configuration and software shall be retained (retention of locally-stored trend data is not required) in the event of a power outage without requiring a download from higher level controllers by one or more of the following means:
   a. Volatile RAM shall have a replaceable battery backup using a lithium battery with a rated service life of 10,000 hours continuous and a rated shelf life of at least 10 years.
   b. Volatile RAM shall have an automatically rechargeable battery backup using a lithium battery with a rated service life of 100 hours continuous and a rated shelf life of at least 10 years.
   c. EEPROM, EPROM, or NVROM non-volatile memory.

2. Provide sufficient internal memory for the specified Sequences of Operations and trend logging, plus an additional 25% free memory capacity to support future programming changes.

K. Trend Logs

1. All controllers shall be able to store trend data locally; network connections shall not be required for trending to occur.
   a. Provide sufficient memory to record the specified number of records (data value and time of occurrence) for each hardware point on the controller (counting every point, not just points currently in use) and an equal number of software points.
   b. Local storage shall be sufficient to record at least one week of data at a 5 minute interval for every required point.
      1) Exception: Application-specific controllers shall have sufficient capacity to record at least one day (24 hours) of data.
   c. Battery-backed or nonvolatile memory is not required for trend storage.

2. All controllers shall support standard BACnet Trend Log and BACnet Trend Log Multiple objects.
3. At each controller, newly acquired trend data shall overwrite the oldest trend data so as to preserve the longest possible contiguous data set in local storage.
L. Runtime Logs: All controllers shall support logging and reporting of runtime for every binary object in the system.
   1. Runtime data shall be sampled and stored in each individual BACnet device using standard BACnet objects and published properties. A separate server or database shall not be required for storage of runtime logs.
   2. Runtime data shall include at a minimum total accumulated active time and total accumulated active transitions since last reset, as well as the timestamp and state for the last 100 transitions on a rolling basis. Runtime data shall be stored in an efficient fashion such that it does not grow with time or consume inordinate amounts of memory on the device.

M. Alarm Processing: Controller software shall support alarm/message processing and buffering as specified. A controller’s ability to report alarms shall not be affected by either operator activity, execution of programs or communications with other controllers on the network.

N. Software Updates and Downloads
   1. Operating System Firmware:
      a. All controllers shall permit operating system firmware updates at any time after installation, utilizing the BACnet network.
      b. Operating system firmware that requires chip replacement or flash modification is not acceptable.
   2. Application Software:
      a. It shall be possible to upload or download site-specific programming (control logic, graphics, schedules, etc.) to/from any controller via direct connection or over the network.
      b. It shall be possible to initiate uploads and downloads manually, via schedule or automatically upon detection of loss or change of programming.

O. Interface Connection: All controllers shall support a communications port for connection of a portable operator’s terminal (POT) or portable operator’s interface device using a physical data link. (Terminal unit controllers may optionally provide this connection via a communicating thermostat.) It shall be possible to perform all program and database back-up, system monitoring, control functions, and controller diagnostics through this port. Connecting to this port shall not interrupt normal operation of permanently connected servers or workstations.

P. Communicating Sensors: All controllers shall support and be capable of monitoring and controlling a network of communicating space sensors without consuming physical hardware input/output points on the device.

Q. Maintenance and Support: Include the following features to facilitate maintenance and support:
   1. Means to quickly and easily disconnect controller from network.
   2. Means to quickly and easily connect to field test equipment.
   3. Means to quickly and easily disconnect sensors, actuators and other attachments from controller.
   4. Visual indication (diagnostic LEDs) that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

R. Self-Test and Failure Response
   1. Each controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
      a. Cease operation
b. Place each point in a predetermined failure state
   c. Generate an alarm notification
2. Each controller shall have resident self-diagnostic software or firmware that can detect an open or shorted sensor circuit and trigger a programmed response.
3. Each controller shall be able to detect a loss of connection to its LAN(s). In that event
   a. Controller shall store the loss of communication alarm along with the time of event, for transmission when network connection is restored.
   b. All control functions shall continue based on last known values or a programmable fail-state value.

S. Loss of Power
1. Controller firmware shall provide for orderly shutdown upon loss of power.
2. Loss of power to any controller shall not adversely affect any other controller.
3. Upon a loss of power, all software, database parameters and data (except locally-stored trend data) shall be protected from memory loss as described previously in this Article.
4. Staggered Start
   a. Upon DDC System startup or restart after power loss, all controllers on the internetwork shall automatically coordinate among themselves to prevent controlled equipment from starting simultaneously.
   b. The operator shall be able to configure the order in which equipment is started and the time delay between start events.
5. When power is restored, controllers shall automatically resume function as described in Paragraph 0.

T. Controller Application Category
1. Permissible controller application categories are based on the type of equipment being controlled and point count, per the following table:

<table>
<thead>
<tr>
<th>Application Category</th>
<th>Examples</th>
<th>Acceptable Controller</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ASC</td>
</tr>
<tr>
<td>0</td>
<td>Monitoring of variables that are not used in a control loop, sequence logic, or safety.</td>
<td>X</td>
</tr>
<tr>
<td>1</td>
<td>• Fan coil units&lt;br&gt;• Terminal units/VAV boxes&lt;br&gt;• Miscellaneous heaters&lt;br&gt;• Exhaust fans and pumps&lt;br&gt;• Packaged units with self-contained controls&lt;br&gt;• Ceiling fans</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>• Lab zones without fume hoods</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>• Air handling units&lt;br&gt;• Hot water/boiler plant&lt;br&gt;• Lab zones with fume hoods&lt;br&gt;• Air-cooled chiller&lt;br&gt;• Any application requiring more than 10 input or 10 output points</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>• Water-cooled chilled water plant&lt;br&gt;• Building-wide supervisory control</td>
<td></td>
</tr>
</tbody>
</table>
2.9 BUILDING CONTROLLERS

A. General
1. A dedicated building controller shall be provided for control of each large point count major mechanical system and/or piece of equipment. See
   a. Multiple pieces of equipment comprising one mechanical system may be controlled by a single building controller provided that all of the points associated with the system are hosted by the controller.
2. Building controllers shall comply with all of the requirements of Paragraph 2.8 as well as the requirements detailed below.
3. Building controllers shall meet the requirements of ASHRAE Standard 135 Annex L for a BACnet Building Controller (B-BC) and support all BIBBs required by that device profile. They shall be certified and listed by the BACnet Testing Laboratories (BTL) as a B-BC prior to the bid date for this Project.
4. All building controllers shall have a real-time clock. Controller shall utilize the BACnet Time Synchronization service and be configurable to adjust automatically for Daylight Savings Time.
5. Each building controller shall have a power switch integral to the controller board, or a separate dedicated switch inside the enclosure.

B. Communication
1. Building controllers shall be peer-to-peer devices that reside on and communicate with other devices on DDC system Supervisory Network or Primary LAN.
2. Building controllers shall also perform routing if connected to a network of advanced application controllers.
3. Building controllers shall provide, at a minimum, the following intrinsic physical network ports which can be enabled and used simultaneously:
   a. One ISO8802-3 Ethernet port capable of at least 100 Mbps.
   b. Two EIA-485 ports capable of at least 76.8 kbps.
4. Building controllers shall provide the following simultaneous communication protocols and/or data links at a minimum:
   a. BACnet protocols:
      1) One BACnet/IP per ASHRAE/ASNI Standard 135 Annex J
      2) One BACnet Ethernet per ASHRAE/ASNI Standard 135.7. BACnet Ethernet may be used at DDC Contractor’s option, but is not required.
      3) Two Master-Slave Token Passing (MS/TP) per ASHRAE/ASNI Standard 135.9
   b. Modbus protocols:
      1) Remote Terminal Unit (RTU) Master or Slave
      2) TCP Master or Slave
   c. Simple Mail Transfer Protocol (SMTP), with at least the following capabilities:
      1) Transport Layer Security (TLS) for SMTP
      2) Compatibility with standard free email services (e.g., Gmail, Yahoo!)
      3) The ability to manage custom TLS certificates from SMTP
      4) The ability to transmit a simple test email to verify SMTP configuration
   d. Simple Network Management Protocol (SNMP)
5. Building controller shall provide stand-alone remote annunciation of alarms via e-mail via SMTP without additional hardware.
6. Building controllers shall support the following BACnet communications services and features in addition to those required for a B-BC device:
   a. Data Sharing Subscribe Change of Value, Client and Server (DS COV A, DS COV B)
   b. BACnet transmit and receive frame segmentation
   c. Post-installation, field-configurable maximum information frames, APDU frame timeout, APDU segment timeout and APDU retries.

C. Input and Output Point Requirements
   1. Each Analog Input point shall have an A/D converter of no less than 12 bits resolution.
   2. Each Analog Output point shall have a D/A converter of no less than 10 bits resolution.
   3. Each controller shall have a minimum of 20% spare input and output points beyond what is required to meet the contract drawings and sequence of operations.
      a. If software-selectable Universal I/O points are available, provide 20% spare UI points and 20% spare UO points.
      b. If software-selectable Universal I/O points are not available, provide 20% spare of each type (AI, AO, BI, and BO) of point.

D. Scheduling: Building controllers shall support the Weekly Schedule and Exception Schedule properties in addition to the requirements of Paragraph 2.8G.
   1. It shall be possible to schedule events based on
      a. A specific date
      b. A range of dates
      c. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any)
      d. Wildcard (example, allow combinations like second Tuesday of every month)
   2. Exception Schedules shall be configurable for any calendar day.
      a. Device shall support a minimum of 100 Exception Schedules.
      b. Each Exception Schedule and holiday shall be individually configurable including name, priority, transition values and times.
      c. The operator shall have the ability to configure Exception Schedules to be active on specific dates, date ranges, recurring date patterns or as commanded by BACnet Calendar objects or other override objects.

2.10 ADVANCED APPLICATION CONTROLLERS

A. General
   1. A dedicated advanced application controller shall be provided for control of each mechanical system and/or major piece of equipment.
      a. A building controller may be used in place of and serve the function of an advanced application controller.
      b. Multiple pieces of equipment comprising one mechanical system may be controlled by a single advanced application controller provided that all of the points associated with the system are hosted by the controller.
   2. Advanced application controllers shall comply with all of the requirements of Article 2.8 as well as the requirements detailed below.
   3. Advanced application controllers shall meet the requirements of ASHRAE Standard 135 Annex L for a BACnet Advanced Application Controller (B-AAC) and support all BIBBs required by that device profile. They shall be certified and listed by the BACnet Testing Laboratories (BTL) as a B-AAC prior to the bid date for this Project.
4. All advanced application controllers shall have a real-time clock. Controller shall utilize the BACnet Time Synchronization service and be configurable to adjust automatically for Daylight Savings Time.

5. Each advanced application controller shall have a power switch integral to the controller board, or a separate dedicated switch inside the enclosure.

B. Communication

1. Advanced application controllers shall be peer-to-peer devices that reside on and communicate with other devices on DDC system Primary LAN.

2. Advanced application controllers shall also perform routing over a Secondary LAN if connected to a network of application-specific controllers.

   a. Advanced application controllers shall be capable of automatically discovering BACnet slave devices on a Secondary LAN and shall be capable of serving as a proxy for BACnet slave devices.

3. Advanced application controllers shall provide, at a minimum, the following intrinsic physical network ports which can be enabled and used simultaneously:

   a. One ISO8802-3 Ethernet port capable of at least 100 Mbps.
   b. Two EIA-485 ports capable of at least 76.9 kbps.

4. Advanced application controllers shall provide the following simultaneous communication protocols and/or data links at a minimum:

   a. BACnet protocols:
      1) One BACnet/IP per ASHRAE/ASNI Standard 135 Annex J
      2) One BACnet Ethernet per ASHRAE/ASNI Standard 135.7. BACnet Ethernet may be used at DDC Contractor’s option, but is required only if needed for compatibility with existing or legacy systems.
      3) Two Master-Slave Token Passing (MS/TP) per ASHRAE/ASNI Standard 135.9

   b. Modbus protocols:
      1) Remote Terminal Unit (RTU) Master or Slave
      2) TCP Master or Slave

   c. Simple Network Management Protocol (SNMP)

5. Advanced application controllers shall support the following communications services and features, in addition to those required for a B-AAC device:

   a. Data Sharing Subscribe Change of Value, Client and Server (DS COV A, DS COV B)
   b. Data Sharing Read Property Multiple, Client and Server (DS RPM A, DS RPM B)
   c. BACnet transmit and receive frame segmentation
   d. Post-installation, field-configurable maximum information frames, APDU frame timeout, APDU segment timeout and APDU retries.

C. Input and Output Point Requirements

1. Each Analog Input point shall have an A/D converter of no less than 12 bits resolution.

2. Each Analog Output point shall have a D/A converter of no less than 8 bits resolution.

3. Each controller shall have a minimum of 20% spare input and output points beyond what is required to meet the contract drawings and sequence of operations.

   a. If software-selectable Universal I/O points are available, provide 20% spare UI points and 20% spare UO points.
   b. If software-selectable Universal I/O points are not available, provide 20% spare of each type (AI, AO, BI, and BO) of point.
D. Scheduling: Advanced application controllers shall support the Weekly Schedule and Exception Schedule properties in addition to the requirements of Paragraph 2.8G.

1. It shall be possible to schedule events based on
   a. A specific date
   b. A range of dates
   c. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any)
   d. Wildcard (example, allow combinations like second Tuesday of every month)

2. Exception Schedules shall be configurable for any calendar day.
   a. Device shall support a minimum of 100 Exception Schedules.
   b. Each Exception Schedule and holiday shall be individually configurable including name, priority, transition values and times.
   c. The operator shall have the ability to configure Exception Schedules to be active on specific dates, date ranges, recurring date patterns or as commanded by BACnet Calendar objects or other override objects.

2.11 APPLICATION-SPECIFIC CONTROLLERS

A. General

1. A dedicated application-specific controller shall be provided for control of each mechanical terminal unit or minor mechanical equipment (e.g. exhaust fan).
   a. An advanced application controller may be used in place of and serve the function of an application-specific controller.

2. An application-specific controller shall not be used for any control task exceeding 10 inputs or 10 outputs. In such cases, an advanced application controller or building controller shall be used.

3. Application-specific controllers shall comply with all of the requirements of Paragraph 2.8 as well as the requirements detailed below.

4. Application-specific controllers shall meet the requirements of ASHRAE Standard 135 Annex L for a BACnet Application Specific Controller (B-ASC) and support all BIBBs required by that device profile. They shall be certified and listed by the BACnet Testing Laboratories (BTL) as a B-ASC prior to the bid date for this Project.

B. Communication

1. Application-specific controllers shall reside on and communicate with other devices on a DDC system Secondary LAN.

2. If connected to a Secondary LAN using BACnet MS/TP protocol:
   a. Controller shall automatically detect the speed (baud) of the MS/TP network and then configure the controller's communication speed to match.
   b. Controller shall be capable of efficiently communicating at a speed of 76.8 kbps under normal network operational conditions with all devices executing the specified sequences of operation at the specified performance criteria.

3. Application-specific controllers shall also communicate with the Primary or Supervisory Network via connection to an advanced application controller or building controller.

4. Application-specific controllers shall provide, at a minimum, the following intrinsic physical network port:
   a. One EIA-485 port capable of at least 76.8 kbps.
5. Application-specific controllers shall provide the following simultaneous communication protocols and/or data links at a minimum:
   a. BACnet protocol: One Master-Slave Token Passing (MS/TP) per ASHRAE/ASNI Standard 135.9
6. Application-specific controllers shall support the following BACnet communications services and features at a minimum:
   a. Data Sharing Subscribe Change of Value, Client and Server (DS COV A, DS COV B)
   b. Data Sharing Read Property Multiple, Client and Server (DS RPM A, DS RPM B)
   c. BACnet transmit and receive frame segmentation
   d. Post-installation, field-configurable maximum information frames, APDU frame timeout, APDU segment timeout and APDU retries.

C. Input and Output Point Requirements
1. Each Analog Input point shall have an A/D converter of no less than 10 bits resolution.
2. Each Analog Output point shall have a D/A converter of no less than 8 bits resolution.
3. Each controller shall have at least one spare AI point and one spare BI point, or one spare UI point, beyond what is required to meet the contract drawings and sequence of operations.

2.12 VAV TERMINAL UNIT CONTROLLERS
A. VAV terminal unit (aka. VAV box) controllers shall meet the requirements for application specific controllers specified above, in addition to the requirements of this Section. Actuators and airflow sensors may be integral to the controller or separate, but shall in all cases meet the requirements outlined below.
B. Damper Actuators: See Actuators in Section 25 30 00.
C. Differential Pressure Airflow Sensor: See Terminal Unit Velocity Pressure Sensor in Section 25 30 00.
D. Test and Balance (TAB) Calibration
1. Airflow sensor calibration shall be performed using the operator’s interface or a dedicated handheld configuration tool connected locally to the air terminal unit.
2. Where dedicated software or hardware is required for airflow sensor calibration, the following must be provided to the Owner as a part of this Specification at a minimum:
   a. One copy of the TAB and airflow calibration software/application. Install software on operator’s portable workstation or on laptop computer provided by Owner.
   b. All software updates and support for five years from the completion and acceptance of the Project TAB report.
   c. See also Paragraph 3.16D.

2.13 LAB CONTROLLERS

2.14 ENCLOSURES
A. General Enclosure Requirements:
1. Products shall be protected with enclosures meeting the following minimum requirements unless more stringent requirements are indicated, or required by the AHJ. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
   a. Outdoors, Protected: Type 4.
   b. Outdoors, Unprotected: Type 4.
   c. Indoors, Heated with Filtered Ventilation: Type 1.
   d. Indoors, Heated with Non-Filtered Ventilation: Type 1.
   e. Indoors, Heated and Air Conditioned: Type 1.
   f. Mechanical Equipment Rooms:
      1) Chiller and Boiler Rooms: Type 3R.
      2) Air-Moving Equipment Rooms: Type 1.
   g. Localized Areas Exposed to Washdown: Type 4.
   h. Within Duct Systems and Air-Moving Equipment: Type 3R.
   i. Within Return Plenums: Type 1
      1) Exception: An enclosure is not required for terminal unit controllers mounted directly to the terminal unit unless ambient hazards dictate otherwise.

2. Include enclosure door with tab and slot for padlock.
3. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.

B. Internal Arrangement:
1. Mount products within enclosure on removable internal panel(s).
2. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components that are associated with a controller, but are not an integral part of controller.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated. Field construction and assembly of enclosures is not acceptable.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals for every unused point on all controllers in the panel.
7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.
9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. Provide enclosure with a line-voltage nominal 20 amp GFCI duplex receptacle for service and testing tools. Install as described in Paragraph 3.11B.5.
11. Provide each enclosure with a surge suppressor, electrical disconnect, control fuse, and control transformer sized as required by the application.
12. Provide permanent identification tags for enclosure, and for control products within enclosure, per Article 3.12.
13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure per Article 3.12.
15. Size enclosure internal panels to provide space to mount one relay for each Binary or Universal Output, including unused or spare points.
16. Provide one spare relay for any panel with 10 or fewer Binary or Universal Outputs. Provide two spare relays for any panel with more than 10 Binary or Universal Outputs.
C. Environmental Conditions:
  1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
  2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.
  3. Enclosure shall be internally insulated if necessary to maintain acceptable operating conditions.
  4. Enclosure shall be ventilated if necessary to maintain operating conditions below maximum operating temperature of product with most stringent requirement.
     a. NEMA Type 1 enclosures may be passively ventilated.
     b. All other enclosures requiring ventilation shall utilize temperature-controlled ventilation fans with filtered louvers. See Paragraph 2.14E.1.
  5. The use of electric heat, air conditioning, or humidification for enclosure environmental control is to be avoided if possible. If application as designed would require these measures, contact Engineer of Record for approval before installing these measures. DDC Contractor is encouraged to suggest changes to design or alternative installation locations that would eliminate the need for these measures. See Paragraphs 2.14E.2, 2.14E.3, and 2.14E.4.

D. NEMA 250 enclosures, All Types:
  1. Enclosure shall be NRTL listed according to UL 50, UL 50E, or UL 508A.
  2. Construct enclosure of minimum 16 gauge steel, stainless steel, or aluminum.
  3. Seam and joints are continuously welded and ground smooth.
  4. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
  5. Corner-formed door, full size of enclosure face. Double-door enclosures shall have overlapping door design to provide unobstructed full-width access. Enclosures more than 36” high shall have continuous piano hinge full length of door.
  6. Gaskets as required to exclude foreign materials in accordance with enclosure Type.
  7. Removable steel or aluminum internal panel with a polyester powder coating that is electrostatically applied and then baked to bond to substrate.
  8. Internal panel mounting hardware, grounding hardware and sealing washers.
  9. Grounding stud on enclosure body.
 10. Thermoplastic pocket on inside of door for record Drawings and Product Data.
 11. Freestanding enclosures shall have
     a. Nominal 4 inch tall integral lifting base with predrilled holes for attachment to mounting surface.
     b. No fewer than two lifting eyes or tabs on top of enclosure.

E. Accessories:
  1. Ventilation Fans, Filtered Intake and Exhaust Grilles:
     a. Number and size of fans, filters and grilles as required by application.
     b. Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.
     c. Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.
     d. Thermostatic control with adjustable set point from 32°F to 140°F.
     e. Maximum operating temperature of 160°F.
     f. Fans shall have thermally-protected split capacitor motors and permanently lubricated ball bearings.
     g. Dynamically balanced impellers molded from polycarbonate material.
Fan brackets, finger guards and mounting hardware provided with fans to complete installation.

Removable Intake and Exhaust Grilles: stainless or chrome steel to match fan size.

Filters: Washable foam or aluminum, of a size to match intake grille.

2. Electric Heater: Not to be installed without written authorization from Engineer of Record. If authorized, heater shall have the following features:
   a. Aluminum housing with brushed finish.
   b. Thermostatic control with adjustable set point from 0°F to 100°F.
   c. Capacity: 100, 200, 400, and 800 watts as required by application.
   d. Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.

3. Air Conditioner: Not to be installed without written authorization from Engineer of Record. If authorized, air conditioner shall have the following features:
   a. Electric-powered, self-contained air-conditioning unit specially designed for electrical enclosures to maintain temperature inside enclosure below ambient temperature outside enclosure.
   b. Thermostatic control with adjustable set point from 60°F to 120°F.
   c. Enclosure side or top mounting with unit capacity as required by application.
   d. Designed for closed-loop cooling with continuous operation in ambient environments up to 125°F.
   e. HFC refrigerant.
   f. Reusable and washable air filter.
   g. High-performance, industrial-grade, and high-efficiency fans.
   h. Furnished with power cord and polarized plug for power connection.
   i. Condensate management system with base pan side drain.
   j. Mounting hardware, gaskets, mounting template and instruction manual furnished with unit.
   k. Outdoor units equipped with head pressure control for low ambient operation, compressor heater, coated condenser coil and thermostat.

4. Thermoelectric Humidifier: Not to be installed without written authorization from Engineer of Record. If authorized, humidifier shall have the following features:
   a. ABS plastic enclosure.
   b. Capacity of 8 oz. of water per 24 hours.
   c. Built-in drain captures moisture and plastic hose directs moisture to outside enclosure through a drain.
   d. Controlled to maintain enclosure relative humidity at an adjustable set point.
   e. Unit power supply shall be internally wired to enclosure electrical power source.

5. Window Kit:
   a. Scratch-resistant acrylic or polycarbonate window, 1/4 inch thick, mounted directly in enclosure door material or in a metal frame matching door material.
   b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.
   c. Window kit shall be factory or shop installed before shipment to Project.

7. Slot and tab latch with identically keyed padlock.

2.15 ELECTRIC POWER DEVICES

A. Power Supplies & Control Transformers
1. Control transformers and power supplies shall be UL-Listed.
2. Provide Class 2 current-limiting type or over-current protection in both primary and secondary circuits for Class 2 service per NEC requirements.
3. Transformer shall be properly sized for application. Limit connected loads to 80% of rated capacity.
4. EM/RF shall meet FCC Class B and VDE 0871 for Class B, and MIL-STD 810C for shock and vibration.
5. Line voltage units shall be UL Recognized and CSA Approved.

B. DC Power Supplies: DC power supply output shall match output current and voltage requirements. Power supply shall be full-wave rectified type with the following minimum Specifications:
   1. Output ripple: 5.0 mV maximum peak-to-peak.
   2. Regulation: 1.0% line and load combined.
   3. Response: 100 ms for 50% load changes.
   4. Built-in overvoltage and overcurrent protection and able to withstand a 150% current overload for a minimum of three (3) seconds without tripping or failure.

C. Power Contactors: General-purpose AC magnetic contactor complying with NEMA ICS 2.

D. Control Relays
   1. All control relays shall be UL listed, enclosed, with LED energized indicator.
   2. All relays shall have contact rating, configuration and coil voltage suitable for the application.
   3. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
      a. AC coil pull-in voltage range of +10%, -15% or nominal voltage.
      b. Coil sealed volt-amperes (VA) not greater than 4 VA.
      c. Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
      d. Pilot light indication of power-to-coil and coil retainer clips.
   4. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load.
   5. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.

E. Uninterruptable Power Supplies
   1. Provide unit with integral line-interactive, power condition topology to eliminate all power contaminants. It shall provide continuous, regulated output power without engaging batteries during brown-out, surge, and spike conditions
   2. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.
   3. UPS shall provide 5 minutes of battery power at connected full load.
   4. UPS shall be Energy Star certified.
   5. Performance:
      a. Input Voltage: Single phase, 120VAC, +20% to -30%.
      b. Power Factor: Minimum 0.97 at full load.
      c. Output Voltage: Single phase, 120 VAC ±3% steady state
      d. On-Battery Output Voltage: True sine wave.
      e. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
      f. Recharge time shall be a maximum of eight hours to 90 percent capacity after full discharge to cutoff.
g. Transfer Time: 6 ms.
h. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.

6. Engagement shall be automatic during fault or overload conditions.
7. Include front panel with power switch and visual indication of power, battery, fault and temperature.
8. Include an audible alarm of faults and front panel silence feature.
9. UPS shall include dry contacts (digital output points) to signal low battery condition and battery on (primary utility power failure).
10. Batteries shall be sealed lead-acid or NiMH type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.

F. Transient Voltage Protection and Surge Suppression Devices
1. Device shall be designated as 120V surge suppression devices for electronic equipment.
2. Devices shall be designed, manufactured, tested and installed in compliance with ANSI/IEEE C62.41 and C62.45, NEMA, NEC and UL 1449 and 1283.
3. Devices must be labeled for UL 1449.
4. Clamping voltage for 120V power systems shall be 400V.
5. Devices shall include visual indicator when surge device has been used and is no longer providing protection.
6. Do not use fuses for surge protection

G. Power Conditioning Devices
1. Devices shall be designated as 120V power conditioning devices for electronic equipment.
2. Devices shall be designed, manufactured, tested and installed in compliance with ANSI/IEEE C62.41 and C62.45, NEMA, NEC and UL 1449 and 1283.
3. Devices must be labeled for UL 1449 and UL 1283.
4. Performance:
   a. At 85% load, output voltage shall not deviate by more than ±1% of nominal when input voltage fluctuates between -20% to +10% of nominal.
   b. During load changes from zero to full load, output voltage shall not deviate by more than ±3% of nominal.
   c. Accomplish full correction of load switching disturbances within five cycles, and 95% correction within two cycles of onset of disturbance.
   d. Total harmonic distortion shall not exceed 3.5% at full load.
5. Devices shall include visual indicator when surge device has been used and is no longer providing protection.

2.16 POWER WIRE AND RACEWAYS

A. Comply with Division 26 requirements for power wiring, and all applicable local codes and/or requirements of AHJ.

B. All insulated wire to be copper conductors, UL labeled for 90 ºC minimum service.

2.17 CONTROL AND COMMUNICATION WIRE AND RACEWAYS

A. General:
1. Comply with Division 26 and Division 27 requirements for low voltage wiring, ANSI/TIA 568 and 607, BICSI Telecommunications Distribution Methods Manual, and all applicable local codes and/or requirements of AHJ.
2. All insulated wire to be copper conductors, UL labeled for 90 °C minimum service.
3. Wire gauge shall be per manufacturer’s recommendations for application and distances installed.
4. Wiring shall be UL Listed for the intended application.
5. Overall flexible, lead-free jacket. For conductors not concealed in raceways, use UL-listed plenum-rated insulation.
6. Continuous runs without splices between termination points.

B. Ethernet LAN: Category 5e or 6 100 Base-T (IEEE 802.3u)

C. MS/TP LAN: 100% shielded twisted pair, rated for maximum planned network speed. Wire shall meet or exceed the requirements specified in Part 9.2.1 of the BACnet standard.

D. Signal wire: 100% shielded

E. Raceways and Conduit: Comply with Division 26 and Division 27 Specifications for low-voltage wiring

2.18 PIPING AND TUBING

A. Pneumatic Control Tubing and Piping:
1. Products in this paragraph are intended for
   a. Main air and signal air to pneumatically controlled instruments, actuators and other control devices and accessories.
   b. Signal air between pressure instruments, such as sensors, switches, transmitters, controllers and accessories.

2. Metal tubing: Copper, Type L hard or soft seamless, ASTM B88
   a. Intermediate connections with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22
   b. Connections to equipment with brass compression-type fittings.
   c. Solder shall be ASTM B32, 95/5 tin antimony, Bridgit or Silvabrite.
   d. Use plastic-coated copper tubing in wet locations.

3. Plastic tubing: Fire resistant virgin polyethylene ASTM D 2737
   a. Self-extinguishing per ASTM D635
   b. Meets stress-crack test ASTM D1693 60T
   c. Use UL 94 flame-retardant harness for multiple tubing.
   d. Use compression or push-on brass fittings.

4. Isolation valves: Threaded or soldered 2-piece bronze ball valves suitable for intended service and pressure.

B. Process Tubing:
1. Products in this paragraph are intended to connect sensors and instruments to liquid and steam systems.
2. Copper Tubing:
   a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered with chemical and physical properties according to ASTM B 75.
b. Performance, dimensions, weight and tolerance according to ASTM B 280.
c. Diameter, as required by application, of not less than nominal 0.25 inch.
d. Wall thickness, as required by application, but not less than 0.030 inch.

3. Copper Tubing Connectors and Fittings:
   a. Intermediate connections with cast-bronze solder joint fittings, ANSI B1.18; or
      wrought-copper solder-joint fittings, ANSI B16.22
   b. Connections to equipment with brass compression-type fittings.

4. Stainless Steel Tubing:
   a. Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled,
      free from scale.
   b. Chemical and physical properties according to ASTM A 269.
   c. Diameter, as required by application, of not less than nominal 0.25 inch.
   d. Wall thickness, as required by application, but not less than 0.035 inch.

5. Stainless Steel Tubing Connectors and Fittings:
   a. Connectors and fittings shall be stainless steel, with stainless-steel collets, flareless
      type.
   b. Connect instruments to tubing with connectors having compression connector on one
      end and IPS or NPT thread on other end.

PART 3 - EXECUTION

3.1 GENERAL

A. The DDC System, all of its components, its execution and compliance with this Section and related Sections is the responsibility of the DDC Contractor.

1. Unless otherwise noted, all DDC System devices and components as required to satisfy the intent of the Sequences of Operations and the requirements of the Contract Drawings and Specification shall be provided as a part of this Section.

2. All control system components shall be installed in locations as required to properly sense the controlled medium and perform according to the intent of the specified Sequence of Operations and the requirements of the Contract Drawings and Specification.

B. All control products shall be assembled in a workshop environment by skilled technicians, and shall be subjected to a quality assurance process by DDC Contractor prior to delivery to jobsite. Field assembly is not acceptable.

1. Control panels and enclosures shall be shop-built by DDC Contractor, and shall be delivered to the jobsite ready for mounting and external wiring connections.

2. Control devices, including sensors and instrument, which are shipped loose shall be assembled/installed in their final configuration to the greatest degree practical.

3. Terminal unit controllers shall be mounted to terminal units by DDC Contractor at his/her shop, or by terminal unit manufacturer at factory. Field installation of terminal unit controllers shall not be acceptable.

C. Install systems and materials in accordance with manufacturer’s instructions, roughing-in drawings, details and control schematics indicated on Contract Drawings.
D. DDC Contractor shall perform Work under this Section in accordance with the following general sequence of events, subject to direction by the General Contractor. Coordination of Work and Project schedule shall be by the General Contractor, but DDC Contractor shall notify the Commissioning Authority and the Engineer of Record if jobsite circumstances, Project schedule, or General Contractor instructions require substantial deviation from this sequence of events.

1. Submit Submittal Package 0 (Qualifications) and receive approval.
2. Submit Submittal Package 1 (Hardware, Shop Drawings, Coordination Plans, Schedule) and receive approval.
3. Initiate installation of DDC System hardware, devices and wiring.
4. Develop point database and application software.
5. Simulate sequencing and debug programming off-line to the extent practical.
6. Submit Submittal Package 2 (Programming and Graphics) and receive approval.
7. Complete installation of DDC System hardware, devices and wiring.
8. Install point database and application software in controllers.
9. Submit Submittal Package 3 (Testing Forms) and receive approval.
10. Perform BAS Pre-functional Tests (start up, calibration and tuning) and submit BAS Pre-Functional Test Report for approval.
12. Assist in TAB tests and setpoint determination as specified in Article 3.4 and Paragraph 3.16D. Submit Setpoint Determination Report for approval.
14. Submit Package 4 (Training Materials) and receive approval.
15. Schedule Demonstration Tests, only after receiving approval of BAS Functional Test Report.
17. Train Owner’s personnel on system operation and maintenance.
18. Provide Completion Requirements documentation including hardcopy to Owner.
19. Provide DDC System access credentials to the Owner per Paragraph 1.9B.4.
20. Submit Package 5 (Post-Construction Trend Logs) in format specified for review and approval.
21. Receive approval of successful Trend Log review, or retest as required.
22. Complete all items in Completion Requirements per Article 1.9 and submit documents (electronically) for approval.
23. Receive approval of Completion Requirements documentation.
24. Provide Completion Requirements documentation including hardcopy to Owner.
25. Update all DDC System Software and device firmware to latest versions.

E. Coordinate Work and Work schedule with other trades prior to construction under the direction of the General Contractor.
3.2 DELIVERY, STORAGE AND HANDLING

A. The DDC Contractor shall be responsible for his/her work and equipment until finally inspected, tested and accepted.

B. The DDC Contractor shall protect his/her work against theft or damage, and shall carefully store material and equipment received on site that is not immediately installed.
   1. Close all open ends of work with temporary covers or plugs during storage and construction to prevent damage/contamination by foreign objects and construction debris.
   2. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment.
   3. Store equipment and materials inside and protect from weather.

3.3 EXAMINATION AND SITE CONDITIONS REPORT

A. The DDC Contractor shall thoroughly examine the Contract Drawings and Project Specification for control device and equipment locations.

B. The DDC Contractor shall inspect the site to verify that the equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be documented and submitted in the Site Conditions Report. If space appears inadequate for installation, including required or indicated clearances, that concern shall be documented and submitted in the Site Conditions Report.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report of site conditions. Report shall describe any conditions detrimental to performance of the Work, or it shall declare that the site conditions have been reviewed and no such detrimental conditions have been identified. Submit report to Engineer of Record for review and approval no later than Submittal Package 2 (see Paragraph 1.8G.1.c.1).

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 COORDINATION WITH OTHER TRADES

A. Where the mechanical work will be installed in close proximity to, or will interfere with work of other trades, the DDC Contractor shall assist in coordinating space requirements.

B. Coordinate and schedule work with all other trades in the same area, or with work that is dependent upon other trades to facilitate mutual progress. Report all conflicts and anticipated delays to the General Contractor for resolution immediately upon identification.

C. Control Products for Factory Installation
   1. Furnish selected control devices and products to equipment and systems manufacturers for factory installation as specified in Contract Drawing equipment schedules and control schematics.
   2. If DDC Contractor is not installing controllers to terminal units at their own shop (see Paragraph 3.1B.3), furnish terminal unit controllers to terminal unit manufacturer for factory mounting and integration. Field installation of terminal unit controllers is not acceptable.
   3. Submit coordination plan for manufacturer integration with DDC Submittal Package 1 (see Paragraph 1.8H.2.f).
a. Coordination plan shall list devices furnished, destination company name and address, and anticipated date of shipment.

4. DDC Contractor is responsible for delivering equipment to manufacturers in a timely fashion to facilitate mutual progress and meet the Project schedule. Immediately notify General Contractor of any anticipated or probable delays in product availability or delivery which could impact construction schedule.

5. DDC Contractor is responsible for coordinating, supporting, and verifying the installation of controls products by manufacturers. Provide all reasonable support required to ensure correct installation of control products.

6. Verify correct function of control products upon receipt of equipment with control product installed.

D. Control Products for Installation by Others

1. Furnish control devices and products to contractors of other trades for field installation as coordinated with those trades or as directed by the General Contractor.

2. DDC Contractor shall meet with contractors of other trades to coordinate details of the interface between the control products and the equipment or location where they are to be installed.

a. The project Commissioning Coordinator as well as the Owner or the Commissioning Authority shall be present for these meetings.

b. DDC Contractor shall provide all information and documentation regarding the correct installation, configuration and operation of said control products.

c. DDC Contractor shall provide details of the proposed interface to the DDC System including PICS for BACnet equipment, hardware and software identifiers for interface points, network identifiers, wiring requirements communications speeds, and required network accessories.

d. DDC Contractor shall review with contractors of other trades the control and interface requirements of the equipment where the control devices are to be installed, to ensure that there are no unresolved issues regarding the integration of these products into the DDC System.

e. Submit coordination plan documenting this meeting with DDC Submittal Package 1 (see Paragraph 1.8H.2.f).

1) Coordination plan shall list devices furnished, the trade to which they are furnished, and the equipment or location where they are to be installed.

2) The coordination plan shall indicate agreement by contractors of other trades to install these devices as discussed in this meeting.

3. If the DDC Contractor is unable to coordinate effectively with contractors of other trades, it is the DDC Contractor’s responsibility to notify the General Contractor and the project Commissioning Coordinator and seek resolution. If coordination remains impossible after such notification, the DDC Contractor shall notify the Commissioning Authority and the Owner in writing.

4. DDC Contractor is responsible for delivering equipment to other contractors in a timely fashion to facilitate mutual progress and meet the Project schedule. Immediately notify General Contractor of any anticipated or probable delays in product availability or delivery which could impact construction schedule.

5. DDC Contractor is responsible for supporting and verifying the installation of controls products by contractors of other trades. Provide all reasonable support required to ensure correct installation of control products.

6. DDC Contractor shall verify correct function of control products after installation.
E. Products by Others for Integration with DDC System

1. As required by the needs of the project or as directed by the General Contractor, DDC Contractor shall coordinate with contractors of other trades who are furnishing equipment that is to be installed or configured by the DDC Contractor, or is to interface with the DDC System network.

2. This requirement applies to all equipment that is installed, configured or connected by the DDC Contractor, including but not limited to VFDs, gateways, and package unit controllers.

3. DDC Contractor shall meet with contractors of other trades to coordinate details of the interface between said equipment and the DDC System.

   a. The project Commissioning Coordinator as well as the Owner or the Commissioning Authority shall be present for these meetings.
   b. DDC Contractor shall obtain from equipment manufacturers and/or other contractors all information and documentation regarding the correct installation, configuration and operation of said equipment.
   c. DDC Contractor shall obtain from equipment manufacturers and/or other contractors details of the proposed interface to the DDC System including PICS for BACnet equipment, hardware and software identifiers for interface points, network identifiers, wiring requirements communications speeds, and required network accessories.
   d. DDC Contractor shall ensure that there are no unresolved issues regarding the integration of these products into the DDC System.
   e. Submit coordination plan documenting this meeting with DDC Submittal Package 1 (see Paragraph 1.8H.2.f).

      1) Coordination plan shall list equipment furnished to the DDC Contractor, the trade or manufacturer providing said equipment, the expected installation location, and the means of connection or interface to the DDC System.

4. If the DDC Contractor is unable to coordinate effectively with contractors of other trades, it is the DDC Contractor's responsibility to notify the General Contractor and the project Commissioning Coordinator and seek resolution. If coordination remains impossible after such notification, the DDC Contractor shall notify the Commissioning Authority and the Owner in writing.

F. Setpoint Determination

1. DDC Contractor and TAB (Test and Balance) Contractor shall coordinate to determine the correct values for setpoints and other parameters required to program Sequences of Operations.

2. DDC Contractor shall provide a list of setpoints and other parameters to be determined by the TAB Contractor.

   a. See “Information to be Coordinated with Test and Balance Contractor” in Part 3 of Sequences of Operations for required setpoints identified by Engineer of Record.
   b. The list of setpoints provided in Sequences of Operations may not be complete. DDC Contractor is responsible for identifying all setpoints which require TAB coordination and are necessary for correct execution of Sequences of Operations.

3. TAB Contractor shall develop necessary test processes and forms in accordance with Division 23. DDC Contractor shall review and comment on planned tests to ensure that they will provide information required to correctly program Sequences of Operations.

4. Submit Setpoint Determination Plan with DDC Submittal Package 3 (see Paragraph 1.8H.4.b). (Plan will also be separately submitted by TAB Contractor under Division 23.)

   a. Plan shall include a brief narrative description of the means and methods to be used to determine specified setpoints and other system parameters.
   b. Plan shall also include copies of the data record sheets to be used during testing.
   c. Coordination plan shall be signed by both DDC Contractor and TAB Contractor.
5. After setpoint determination is complete, provide Setpoint Determination Report. See Paragraph 3.16D.3.

G. Life Safety: DDC System provided under this Section is not rated for and shall not perform life-safety control functions. The control system shall interact with life-safety systems only via hardwired interlock, or for monitoring purposes, as detailed below.

1. Duct smoke detectors required for air handling unit shut down are provided under other Divisions and Sections of this Specification. The DDC Contractor provide a hardwired interlock from duct smoke detectors to shut down HVAC equipment as shown in the Contract Drawing control schematics.

2. Fire/smoke alarm system is provided under another Division of this Specification. The DDC Contractor shall provide a hardwired interlock from nearest fire alarm panel to shut down HVAC equipment as shown in the Contract Drawing control schematics.

3. Smoke and fire-smoke duct isolation dampers and actuators are provided under other Divisions and Sections of this Specification. No BAS connection is required or permitted.

H. Networked Lighting Control System Integration

1. As shown in Contract Drawing control schematics, connect to lighting control system and map across points as indicated and as required to execute control logic described in Sequences of Operations.

2. Map all points shown on Contract Drawing control schematics from lighting control system to BAS. At a minimum (regardless of control schematics), for each room under the lighting control system, map the following points:
   a. Lighting zone status
   b. Occupancy sensor status, if applicable
   c. Local switch status, if applicable
   d. Room ambient light level, if applicable
   e. Dimming level (dimming percent or number of fixtures energized)
   f. Lighting zone demand response status

3. All points mapped from the lighting control system shall be trended in accordance with Paragraph 3.6E.

4. For each lighting control zone, map the lighting schedule to a schedule in the BAS. Schedule mapping shall have read/write capability so that changes made at the BAS are reflected in the lighting control system and changes made in the lighting control system are reflected in the BAS. In other words, lighting schedule shall be synchronized between BAS interface and lighting control system interface.

5. Coordinate with Division 26 and submit coordination plan for lighting system integration with DDC Submittal Package 1 (see Paragraph 1.8H.2.f).
   a. A coordination meeting with Division 26 is strongly encouraged.
   b. Plan shall include a narrative description of the expected tie ins between the DDC System and lighting control system, along with a list of points to be mapped, and schematics and drawings as required to support a seamless integration.
   c. Coordination plan shall be signed by both DDC Contractor and Division 26 Contractor.

I. Resource Meter Integration

1. As shown in Contract Drawing control schematics, connect to pulse output of utility water, gas or electric meters installed by others. Coordinate with appropriate trades and/or utilities to determine quantity of resource represented by each pulse. Trend cumulative consumption of each meter separately. Verify that consumption reported by DDC System matches actual meter reading. Submit verification with Functional Test Report.
2. As shown in Contract Drawing control schematics, connect electric circuit power meters, "smart" breakers, and network-enabled meters to DDC System.
   a. Networked-connected resource meters shall communicate using native BACnet without requiring a protocol translator. See Paragraph 2.7E.
   b. Coordinate with Division 26 to install and test, and submit coordination plan for meter integration with DDC Submittal Package 1 (see Paragraph 1.8H.2.f).
      1) A coordination meeting with Division 26 is strongly encouraged.
      2) Plan shall include a narrative description of the expected tie ins between the DDC System and meters, along with a list of points to be mapped, and schematics and drawings as required to support a seamless integration.
      3) Coordination plan shall be signed by both DDC Contractor and Division 26 Contractor.

3. After installation, verify that information reported by DDC System matches actual consumption. Submit verification with Functional Test Report. DDC Contractor is responsible for ensuring accuracy of meter information reported by DDC System.

J. Testing and Commissioning
   1. Coordinate with and assist TAB Contractor in balancing tasks which require DDC System interaction per Paragraph 3.16D.
   2. Perform commissioning activities and assist Commissioning Authority and/or Commissioning Coordinator in the execution of commissioning tasks per Article 3.16.

3.5 GENERAL WORKMANSHIP REQUIREMENTS

A. DDC System installation shall be performed by professionals in a workmanlike manner consistent with industry standards for performance and in compliance with the Contract Documents, Division 26 and 27 Specifications, the National Electric Code (NEC) and any/all applicable local codes and/or Authorities Having Jurisdiction.

B. DDC Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

C. Installation of all control devices and products shall follow manufacturer’s recommended installation procedures. If there is a conflict between manufacturer’s recommendation and any Specification, code requirement or AHJ requirement, notify the Engineer of Record in writing.
   1. DDC Contractor shall have all work inspected as required by local and/or regional code enforcing authorities and/or AHJ.

D. Install products to satisfy more stringent of all requirements indicated.

E. Install products level or plumb, parallel or perpendicular to building construction.

F. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment. Comply with all seismic requirements.

G. Penetrations
   1. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required for installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
   2. Firestop penetrations made in fire-rated assemblies. Comply with Division 7 requirements.
3. Seal penetrations made in acoustically rated assemblies. Comply with Division 7 requirements.
4. Penetrations through and mounting holes in the building exterior associated with the DDC System installation shall be sealed and made water-tight.

H. Provide sufficient slack wire and flexible connections to allow for vibration of piping and equipment.

I. Dielectric isolation shall be provided where dissimilar metals are used in installation for connection and support.

J. Welding Requirements:
   1. Restrict welding and burning to supports and bracing.
   2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
   3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
   4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

K. Fastening Hardware:
   1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
   3. Lubricate threads of bolts, nuts and screws with graphite before assembly.

L. Install products in locations that are readily accessible as defined by Chapter 1, Article 100, Part A of the National Electric Code (NEC) and that will permit service, maintenance, repair or replacement from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

M. All control devices mounted outdoors shall be protected by a weather-shield, integral outdoor enclosure, etc. and from ambient elements in such a manner as to not impede design functionality and/or sensing. See Paragraph 2.2H.

N. Corrosive Environments:
   1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:
      a. Laboratory exhaust-air streams.
      b. Process exhaust-air streams.
   2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive resistant epoxy coating.
   3. Where products are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.
O. Cleaning

1. Clean up all debris resulting from its activities daily. Remove all cartons, containers, crates, and other debris generated by Work in this Section as soon as their contents have been removed. Waste shall be collected and disposed of in accordance with Project waste disposal procedures. All recyclable materials shall be sorted into the appropriate bins.

2. Materials stored on-site shall be protected from weather and stored in an orderly manner, neatly stacked, or piled in the designated area assigned by the Owner’s Representative.

3. At the completion of work in any area, clean all work and equipment of dust, dirt, and debris.

4. Use only cleaning materials recommended by the manufacturer of the surfaces to be cleaned and on surfaces recommended by the cleaning material manufacturer.

P. All damage to and openings in ductwork, piping insulation, and other materials and equipment resulting from Work in this Section shall be properly sealed, repaired, or re-insulated by experienced contractors of the trade involved. Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

Q. At the completion of Work, all equipment furnished under this Section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired and repainted to original finish.

3.6 SYSTEM SOFTWARE INSTALLATION

A. General

1. DDC Contractor shall install and completely configure all System Software, supplemental software, networking stacks and interfaces on all servers and interface devices specified in this Section.

2. DDC Contractor shall tune and adjust software as required to obtain a fully functioning system that provides stable control.

3. Maintain all programming, graphics and data files in a logical system of directories with self-explanatory file names.

4. All programming developed for the Project is the property of the Owner, per Article 1.10.

B. System Software Packages

1. Operator’s Web Interface (OWI): Provide and configure per Paragraph 2.4B.

2. BACnet Advanced Operator Workstation (B-AWS): Provide and configure per Paragraph 2.4C.

3. Simulation Tools: Provide and configure if required in Paragraph Error! Reference source not found.

4. Trend Archive Software:
   a. Provide if required in Paragraph 2.4D. If “Not Required” then DDC Contractor may disregard the remainder of this Paragraph.
   b. Configure to automatically manage network connections, retrieve data at configured intervals, and store data in provided SQL Trend Database.
   c. Software shall identify any of the following fault conditions and generate a Level 4 alarm at the operator’s graphical interface.
      1) Communication failure
      2) Corrupt data is retrieved from control device
      3) Device is offline unexpectedly
      4) SQL database/access errors
      5) Archive service failures
d. In the event of a database access failure, the Trend Archive software shall build a storage queue of data to be written to the SQL database when it becomes available.

5. Trend Database Software

a. Provide and configure if required in Paragraph 2.4E. If “Not Required” then DDC Contractor may disregard the remainder of this Paragraph.

b. If database software limits the size of the database file, configure system to automatically create and start using a new database file when the current file approaches maximum size, so that multiple database files shall reside on Data drive. Generate a Level 5 alarm notification when this occurs.

c. Configure database to perform the following functions automatically without user intervention:

1) Regularly perform automatic database integrity checks. In the event of a failed integrity check, generate a Level 3 alarm.

2) Configure database so that, in the event that it runs out of space, oldest data is overwritten by newest data so that the longest possible continuous data record is maintained. If this occurs, generate a Level 4 alarm noting that storage is full. This alarm shall recur no more often than once per week.

6. Trend Analysis Software

a. Provide and configure if required in Paragraph 2.4F. If “Not Required” then DDC Contractor may disregard the remainder of this Paragraph.

b. Trend Analysis and Reporting (TAR) software shall provide fully-customizable analysis and reporting of trend and runtime log data from multiple data sources in standard data formats. The use of proprietary data formats is not acceptable.

c. Reports shall be generated in HTML format natively. Reports shall be converted to PDF when transmitted as email attachments.

d. It shall be possible to filter data by name, mnemonic, object instance and engineering units at a minimum. Users shall have the ability to define persistent filters with custom names for simple organization and access.

e. TAR software shall support the display of user-defined data in each report including static values, dynamic archived data, calculations and formulas with the following capabilities at a minimum.

1) Display data as bar, pie and line charts and in a tabular format.

2) Display raw data with sample date and time stamps.

3) Apply mathematical functions, transforms and conditional operations to data.

4) Filter data based on inequalities, including ranges (e.g. filter for values greater than X and less than Y).

5) Display data at user-defined sample intervals over a customizable date range. (e.g. daily energy consumption for one month).

6) Display data as a contribution by comparing data for a configurable time period (e.g. energy sub-meters as components of total energy consumption for the month).

7) Display data as an aggregate value for a user-defined day, week, month or year over a configurable time period (e.g., analyze energy costs on Monday mornings for the year to optimize system initialization).

8) Interactive, dynamic report-sourced data field components that can be modified by report users for analysis of imported data (e.g., current price of energy or energy conservation measure efficiency).

9) Interactive, dynamic component that can be manipulated by report users for adjusting the displayed date range of the report.

10) Formatted WYSIWYG custom text field for the addition, modification of descriptive text, report narratives, contact information, corporate/client letterhead, hyperlinks, etc.
11) GIF, JPG and/or PNG image components, and customizable text, images, and watermarks.

f. Graphical displays of data shall have at least the capabilities described in Paragraph 2.4B.7.b.

g. DDC Contractor shall provide pre-built sample templates for each of the specified report components for easy replication by report software users.

h. Report format and data shall be fully customizable by the user including the following at a minimum:

1) Custom component, chart, background and line colors.
2) User-defined component, data, legend, title and axis labels.
3) User-defined font and font size.

i. Reports shall be created through a simple drag-and-drop, graphically-oriented operator interface.

j. Any report shall support a minimum number of unique, active data objects totaling the greater of 100 objects or 10% of the total number of hardware objects installed as Work under this Section.

k. Report templates and individual reports shall be saved to the Data Archive server. Authorized users shall be able to characterize reports by report title, report author, user-defined category, created and updated dates.

l. TAR software shall support automated e-mail distribution of any report as a hyperlink or PDF attachment to a user-defined recipient list at configurable times, days and dates with custom messages.

C. Security

1. System security permissions shall be multilayered, supporting at least 5 access levels with distinct viewing and editing privileges definable for each level. Initially define the following access levels:

a. Observer: Can view all parts of the DDC System interface but cannot override points, or issue commands or exert other control functions.

b. Regular Operator: Observer access plus the ability to perform all tasks listed in Paragraph 3.17D.3.

c. Advanced Operator: Observer access plus the ability to perform all tasks listed in Paragraphs 3.17D.3 and 3.17D.4.

d. System Administrator: Observer access plus the ability to perform all tasks listed in Paragraphs 3.17D.3 and 3.17D.5.

e. Superuser: Full and unrestricted access to all control system functions.

2. Each operator shall be required to log on to the system with a unique user name and password in order to view, edit, add or delete data.

3. User registration shall require an email address associated with each user, which is used to notify operator of errors and alerts as described elsewhere in this Section.

4. DDC Contractor shall coordinate with Owner or building maintenance staff for initial users, passwords, email addresses and associated access levels.

a. DDC System user/password database must be configured before system acceptance.

b. Configure exactly one (1) Superuser account (see above) in addition to accounts requested by Owner.

c. The usernames “admin” and “administrator” shall not be used. If either username is hard coded into the software, disable the associated account and create a new account with equivalent privileges under a different username.

d. Default passwords shall not be used and shall be changed if present.

e. Passwords assigned to each user shall be unique to that user. Use minimum 8 character passwords.
5. All System Software Functions and host devices shall share a common set of usernames and passwords. The user database shall synchronize automatically and transparently among the devices hosting these functions.
6. Active Directory integration support shall be provided for assigning and enforcing security credentials and policies for operators.
7. Each operator shall be automatically logged-off of the system after a configurable period of inactivity.
8. Security data shall be stored and transmitted in an encrypted format, with 256 bit encryption.
9. Provide credentials information to Owner at closeout per Paragraphs 1.9B.4 and 1.9C.2.

D. Sequences of Operation Programming
1. Create controller application programs as required to execute specified Sequences of Operations.
2. Program all Sequences of Operations as written. It is the Contractor’s responsibility to request clarification when clarification is needed.
3. Embed comment statements in the programming sufficient to clearly describe each Section of the program. Comments shall reflect the language of the specified Sequences of Operations.
4. All setpoints, timers, deadbands, PID gains, and other parameters shall be adjustable by a properly-credentialed operator, whether or not they are indicated as adjustable in sequences. Software points shall be used for these variables. Fixed scalar numbers shall not be embedded in application programs except for physical constants and conversion factors.
5. All programming specific to the Project shall be written in a manner that will ensure programming quality and uniformity. Contractor shall ensure:
   a. Programs are developed by one programmer, or a small group of programmers with rigid programming standards, to ensure a uniform style.
   b. Programs for like functions and similar equipment are identical, to reduce debugging time and to ease maintainability.
      1) When there are small variations in equipment configuration (e.g. VAV zone with a CO2 sensor vs. VAV zone with an occupancy sensor), provide a single program with a software “switch” to set operating configuration, rather than providing two separate programs.
   c. Programs are thoroughly debugged before they are installed in the field.
6. Document all programming and configuration as built, and submit for review and approval at the following Project stages:
   a. Prior to downloading into the panel, with Submittal Package 2 (Paragraph 1.8H.3.c)
   b. At the completion of Functional Performance testing, after all remediation and corrections are complete and Functional Test Report has been accepted.
   c. At the end of the warranty period (see Paragraph 1.12B.5).
7. Provide a search capability that will search all control sequences for a given point name to determine all sequences that use or control the point.

E. Trends
1. DDC System shall support trend logs using standard BACnet trend objects, per Paragraph 2.8K.
2. Trend data shall be sampled and stored in controller memory. If Data Archive Server is provided, trend data shall be uploaded from panels to server on a user-defined interval, manual command, or automatically when the controller trend buffer becomes full.
3. All time-basis trends shall be synchronized so as to record data at the same time for ease of side-by-side comparison. Trends with the same time basis but offset timestamps (e.g. one point trends at 1:00, 1:05, 1:10, etc while another point trends at 1:02, 1:07, 1:12, etc.) shall not be accepted.

4. DDC Contractor shall set up trends for all points listed in points schedules on Contract Drawing control schematics. Unless otherwise indicated, trend all listed points as follows:
   a. Binary points shall be trended on a change-of-value (COV) basis.
   b. Analog points shall be trended on a time basis with a frequency of 5 minutes.
   c. If an analog point is indicated for COV trending with a value in engineering units (e.g. “2°F COV”), provide trend which records a timestamp and point value every time the point value changes at least the given increment.
   d. If an analog point is indicated for COV trending with a percentage value (e.g. “±10% COV”), provide trend which records a timestamp and point value every time the point value changes by at least that percentage of its current value.

5. In addition, DDC Contractor shall set up trends of setpoints as follows:
   a. All fixed setpoints shall be trended on a COV basis, with one minimum of one data point recorded per day, at noon. (The minimum single data point provides a reference for subsequent trend analysis.)
   b. All occupant-adjustable setpoints (e.g. at thermostats) shall be trended on a COV basis, with one minimum of one data point recorded per day, at noon.
   c. For setpoints that are reset by a parameter (e.g. reset supply air temperature setpoint based on outdoor air temperature), trend both the setpoint and the resetting parameter on a time basis. Setpoint trend frequency shall be the same as the trend frequency for the physical point controlled by the setpoint, typically 5 minutes.
   d. For setpoints reset by Request-based Trim & Respond logic (see Paragraph 1.4II), trend the setpoint and the number of requests on a time basis. Trend frequency shall be equal to the time step of the Trim & Respond loop.

6. In addition, DDC Contractor shall set up trends of system parameters including the following:
   a. Trend signal value for all control loops, except those that drive a single AO point that is already being trended.
      1) For example, do not trend both the speed of a fan and the analog output of the point commanding the fan speed, as their values will always be the same.
      2) For example, do trend the value of zone heating and zone cooling PID loops, as their output does not correlate directly to any command sent to physical equipment.
   b. Trend all global overrides such as demand response signals and after-hours (i.e. “janitor button”) system operation.
   c. Trend all performance calculations, such as equipment efficiency or plant load, described in Sequences of Operations.

7. In addition, DDC Contractor shall map and set up trends of all equipment points listed in “Trends” in Part 1 of Sequences of Operations.

8. DDC Contractor shall not create duplicate trends of a single point. If a single point referenced for trending in this or other Sections appears more than once, that does not indicate that multiple trends shall be created. Create only one trend for any given physical or virtual point, unless specifically instructed otherwise.
F. Groups

1. As described in Paragraph 2.4C.4, properly-credentialed operators shall be able to assign BACnet objects, parameters or points to groups manually, by type, or using wildcard search, and shall be able to apply batch modifications or overrides to an entire group with a single action.

2. DDC Contractor shall configure the following groups:
   a. All zones, by Zone Group: Assign each zone to a Zone Group, as defined in the Sequence of Operations.
   b. All zones by floor
   c. All equipment by system/function
      1) Assign all devices associated with each major system or subsystem (e.g. chiller plant, boiler plant, air handler) to a separate group.
      2) If there are multiple independent units (e.g. air handlers), create a separate group for each one. If there are multiple interdependent units (e.g. boilers in a plant) put all interdependent units in the same group.
      3) Include with each system group all associated devices (e.g. pumps for plants) and sensors (including physically distance differential pressure or flow sensors, if used for control).
      4) For each air handler, all terminal units for a given air handler should be in a distinct group; i.e. separate from the air handler (so that overrides can be applied to the terminal units) and separate from groups of terminal units associated with other air handlers.
   d. All equipment by floor: Assign all networked control devices to a separate group based on the floor that the device serves (not necessarily where the device is physically located).

3. A single object or point may belong to more than one group. If multiple overrides conflict on a single object, the one with the highest assigned priority shall prevail.

G. DDC System Timekeeping

1. DDC Contractor shall provide a time master that is installed and configured to synchronize the clocks of all BACnet devices.
2. All trend sample times shall be synchronized.
3. The frequency of time synchronization message transmission shall be selectable by the operator.
4. System shall automatically change time/date for Daylight Savings Time and leap years.
5. Also see Paragraph 2.8G.4.

H. Schedule Configuration

1. Configure normal operating schedules. Schedules shall be applied to zone scheduling groups (see Paragraph 3.6F) as described in Sequences of Operations.
2. Configure holiday schedules for federal and state holidays, unless otherwise noted or instructed by Owner.
3. Configure exception schedules as requested by Owner.
4. The schedule objects shall reside in each individual controller or device. Each controller shall locally store schedule objects related to its controlled equipment or systems.

I. Alarm/Event Programming, Configuration and Handling

1. Contractor shall define five alarm levels/categories:
   a. Level 1: Critical/life safety
   b. Level 2: Significant equipment failure
   c. Level 3: Non-critical equipment failure/operation
2. DDC Contractor shall program alarms and associated alarm levels per Sequences of Operations using BACnet Event templates as described in Paragraph 2.2H.3. Alarm messages shall use verbose English language names and descriptions such that the source, location and nature of the alarm is easily understood.

3. Adjust alarm parameters as required to minimize nuisance alarms while identifying genuine alarm and fault conditions.

4. DDC Contractor shall configure alarm handling as follows:

<table>
<thead>
<tr>
<th>Criticality</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4 &amp; 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm</td>
<td>Critical</td>
<td>Not Critical</td>
<td>Not Critical</td>
<td>Not Critical</td>
</tr>
<tr>
<td>Acknowledgement</td>
<td>Required*</td>
<td>Required</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>Acknowledgement of Return to Normal</td>
<td>Required*</td>
<td>Not Required</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>Notify by email?</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Notify by pager/text/SMS?</td>
<td>Y**</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Notify by pop-up at graphical interface</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Remove from current alarm log</td>
<td>After Acknowledged</td>
<td>After 2 weeks</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Level 1 alarms must be acknowledged individually.
**Level 1 alarm notifications shall repeat every hour until acknowledged.

5. Notifications shall be sent to all users of Advanced Operator or higher access level (see Paragraph 3.6C.1) or otherwise as specified by Owner.

6. See Paragraph 3.7L for alarm interface requirements.

J. Graphics Library

1. DDC Contractor shall provide a library of standard HVAC graphic components for the future creation of custom graphics that are consistent with the delivered graphical user interface.

2. Graphical elements shall be professionally rendered isometric three-dimensional static and animated images in a standard (e.g. JPEG, GIF, BMP or PNG) graphics format.

3. Graphic library shall include all of the equipment images and symbols used in the Project, as well as all standard symbols and images for common components (e.g. dampers, valves, sensors) even if they were not used in the delivered graphical user interface.

4. Newly created graphics shall be able to be fully integrated with existing graphics and user interface elements. System shall allow user to attach animations, BACnet objects, points and hyperlinks to graphics.
3.7 GRAPHICAL USER INTERFACE

A. General

1. Graphical user interface shall be an intuitive multi-window image-based interface for navigating, monitoring, and controlling devices within the DDC System.
   a. Interface shall be constructed to have the look and feel of a single application. All graphical screens shall be designed and laid out to provide a uniformly high quality and consistent user experience across displays for different systems.
   b. Graphical elements shall be hyperlinked such that clicking on an element will “drill down” to the next level of detail. (E.g. clicking on an air handler graphic in a system-level schematic will display the interface screen for that air handler; clicking on a fan icon will display detailed information about that fan and its associated VFD.)
   c. When clicking a link, the operator shall have the option of opening the new view in the same window, or in a new window with e.g. a right-click selection. The default shall be to open the new view in the same window.
   d. Every page shall have a “back” button to return to the previous screen and a “home” button to return to the top level or site overview page.
   e. Use colors in a consistent, logical and intuitive way.

2. On all screens, status lamps and displayed text associated with a device (e.g. fan status, or sensor reading) shall correspond to the condition of the device:
   a. Normal operation: Text shall be white, black or other neutral color as appropriate to the background. Status lamps shall be green, or operation may be indicated by an animation.
   b. Manually disabled or offline: Grey (select a shade that provides visible contrast with the background).
   c. Level 1 or Level 2 alarm condition: Red text and lamp.
   d. Levels 3 through 5 alarm condition: Yellow text and lamp.

3. All equipment shall be identified on graphics by the unit tag as scheduled on the drawings.
4. All devices and controlled equipment that appear multiple times (e.g. VAV boxes) shall use a single graphic template so that any updates are automatically applied to all applications with a single action. Displayed points shall be automatically populated using wild cards for point names in graphic template.
5. Display global readings such as time, outdoor air temperature, humidity, and wind speed (as applicable/available) in the upper left corner of every graphic page.
6. Clicking on the display of any point on any graphics page shall open an override screen as described in Paragraph 3.7B.7. It shall be possible to override any input or output, hardware or software point as required by Paragraph 2.2F.
7. Any point that is overridden by the operator shall indicate the overridden condition on every graphic page where that point appears. Override shall be indicated by flashing icon or text, or other means so that status is visually obvious at a glance.
8. If controllers support supervised manual override, points in supervised manual override shall also be indicated on graphics, in a fashion similar to but distinct from operator overrides performed through the DDC System interface.
9. For each graphic page, provide a text box for use by operators to record operational notes about the system. Text box shall expand or scroll in order to accommodate an arbitrary amount of text, without covering or obscuring system graphics.
10. All users shall be required to log in with proper credentials per Paragraph 3.6C to access any control graphic.
11. Contract Drawings in AutoCAD format will be made available to DDC Contractor upon request for use in developing backgrounds for graphic screens. These drawings are provided without guarantee that they will be suitable for the Contractor’s purpose.
B. I/O Points and Setpoints

1. The current value and point name of every I/O point and setpoint shall be shown on at least one graphic page and in its appropriate physical location relative to building and mechanical systems.

2. Verbose names (English language descriptors) shall be included for each point on all graphics. This may be accomplished by a pop-up that appears when hovering the mouse over the displayed point.

3. All analog points and setpoints shall be displayed with appropriate engineering units.

4. For all controlled analog points, display the current setpoint adjacent to the current value of the point.

5. Adjustment of Setpoints: All setpoints shall be adjustable directly within the graphics screen where they appear. It shall not be necessary to open a separate window to make a setpoint adjustment.
   a. Adjusting a setpoint is not the same as overriding it. It shall be possible to override a setpoint (see below) as well, but overrides shall not be used in place of adjustable setpoints. Both features shall be provided.
   b. Adjustments are permanent until changed.
   c. Fixed setpoints shall be adjustable.
   d. For setpoints that are reset by another parameter, both the setpoint range and the reset parameter range shall be adjustable. E.g. If a supply temperature setpoint is reset by outdoor air temperature, it shall be possible to adjust the minimum and maximum values of the supply temperature setpoint and also to adjust the minimum and maximum values of outdoor air temperature against which the setpoint is reset.
   e. For setpoints that use a Request-based Trim & Respond reset logic (see Paragraph 1.4II), all parameters shall be adjustable.
   f. For setpoints that automatically reset, it shall be possible to use an override to lock the current setpoint to a fixed value.
   g. It shall be possible to constrain the range of a setpoint in programming, such that it cannot be adjusted outside of this range. Setpoints shall be able to be overridden to any value irrespective of these constraints.

6. For all setpoints, display the original as-designed or as-balanced setpoint next to the current setpoint. The as-designed setpoint is for reference by future operators and is static: it is not used for control and shall not be able to be adjusted or overridden – the use of an image element rather than a BACnet object is recommended. The as-designed setpoint shall be clearly identified as such.

7. Override of Points: All physical and virtual points shall be able to be overridden per Paragraph 2.2F
   a. When any point is clicked on any graphics page, open a window that displays all of the object’s BACnet properties with an interface allowing points to be locked, overridden or returned to automatic control.
   b. The operator shall be able to establish timed overrides which automatically release after a period of time, and indefinite overrides which remain in effect until released or changed.
   c. Overrides shall require the user to click accept/apply before changes take effect. In other words, simply changing a value in a dialog box does not trigger the override – the operator must positively apply the change.
   d. A point in override shall indicate that status on every page where it appears, as described in Paragraph 3.7A.7 and shall appear in the summary of overridden points, as described in Paragraph 3.7J.9.
C. User Interface Architecture

1. Interface shall consist of a collection of graphical interface pages that provide the operator with various ways to view and control the DDC System and its components, as described below.

2. Graphical interface pages shall be displayed in a multi-window environment to support operator multi-tasking.
   a. User shall be able to close any window without affecting other windows.
   b. User shall be able to minimize any window without closing it.
   c. Interface shall be able to support an arbitrary number of windows, limited only by the memory and processor capacity of the host computer.

3. Graphical interface pages shall be connected by hyperlinks. When following a link, the user shall be able to choose to open the new interface page in a new window or in the same window.

4. Each window shall be to display a variety of graphical interface pages serving different purposes, including at least the following:
   a. Site and building overviews as described in Paragraph 3.7D
   b. System navigation tree as described in Paragraph 3.7D.3
   c. BACnet network map as described in Paragraph 3.7F
   d. Floor plan graphics as described in Paragraph 3.7G
   e. Equipment graphics as described in Paragraph 3.7H
   f. Controller and network device graphics as described in Paragraph 3.7I
   g. Summary pages as described in Paragraph 3.7J
   h. BACnet properties and point overrides as described in Paragraph 3.7B.7
   i. Schedules: Create, modify, view and apply normal, holiday and exception schedules as described in Paragraph 3.7K.
   j. Alarms/Events: View, sort and acknowledge current and historical events. See Paragraphs 3.6I and 3.7L.
   k. Trend and Runtime Logs: Create new trend logs, and display current or historical trend and runtime data, including control of colors, date range, axis and scaling, as specified by Paragraphs 2.4B.7 and 2.4C.8.
   l. Logic Programming and Configuration: An interface for programming controllers with sequence of operation logic per Paragraphs 2.4C.3 and 3.6D.

D. Site/Building Overview

1. If DDC System serves multiple buildings, provide a site overview graphic showing at least all connected buildings. Clicking on a building shall display the associated building overview graphic. If DDC System serves only one building, site overview may be omitted.

2. For each building, provide an overview consisting of floorplan(s) with all mechanical equipment shown in its approximate physical location.
   a. Clicking on any equipment shall open the associated equipment control graphic (Paragraph 3.7H).
   b. For each floor, provide a “zone map” button to open the floor plan graphic (Paragraph 3.7B).
      1) If there are multiple zone types, provide a compound button or multiple adjacent buttons so that user may select the zone map for a specific type of zone.
      2) If there is only one zone type and space permits, the building overview may be combined with the floor plan graphic described in Paragraph 3.7G. All equipment and all zones must be easily identified and selected.
   c. If utility meters are connected to DDC System, display real-time data on building overview roughly where physical utility connection occurs.
d. Multiple floors may be shown in a single overview as long as all elements are large enough to easily see and select.

3. Display global readings such as outdoor air temperature, humidity, and wind speed (as applicable) prominently on site overview and each building overview.

E. System Navigation Tree
1. Provide hierarchical "tree" of equipment controlled by DDC System, similar to the Windows Explorer navigation tree.
2. Tree structure shall be based on the physical relationships between the devices being controlled (e.g. the VAV boxes served by an AHU shall be shown as "children" of that AHU).
3. Only controlled equipment and devices that provide control functions shall be displayed in this view. Devices dedicated to routing, protocol translation or other pure networking functions shall not be displayed.
4. Zones may be displayed in relation to their terminal units if doing so does not clutter the interface. Doing so may not be appropriate if there are multiple zone types, or if the relationship between zones and terminal units is not straightforward.
5. Display each piece of equipment as a separate object, even if they are attached to the same controller (e.g. multiple pumps serving a single plant shall be shown individually, as "child" objects of the plant equipment that they serve).
6. Navigation tree shall support expansion and collapse of individual levels of the tree, or of all levels simultaneously.
7. Clicking on any element of the tree shall open the graphic page for that equipment or zone.

F. Network Map
1. Provide an interactive graphical map of DDC System devices based on the actual connectivity of the BACnet internetwork.
2. Show all BACnet networked devices including routers, switches and controllers.
3. Show actual network architecture, including Supervisory Network (if applicable) and all Primary and Secondary Control LANs, with controllers as connected.
4. Clicking on any element shall open the graphic page for that controller or network device (Paragraph 3.7I).

G. Floor Plan Graphics
1. For each floor, provide one or more zone maps overlaid on floor plan graphics.
   a. Contract Drawing mechanical plans may show multiple types of zone (See Paragraph 1.4SS). In that case, provide color coded zone maps for each type of zone as described below.
   b. If mechanical plans do not distinguish between Thermal Space Control and Ventilation zones, assume that each non-Radiant zone combines the characteristics of both a Thermal Space Control zone and a Ventilation zone. (This is the case for conventional VAV zones.) The map of these zones shall display the information listed in both Paragraphs 3.7G.2 and 3.7G.3.
2. Thermal Space Control Zones
   a. Provide separate zone map for Thermal Space Control zones as shown on plans.
   b. Display the associated zone (air) temperature and setpoint at each zone.
   c. Also indicate zone temperature relative to active (occupied or unoccupied) setpoint graphically by coloring the zone area according to the following scheme:
      1) Red: Space temperature is above cooling setpoint by more than the adjustable threshold.
      2) Yellow: Space temperature is above cooling setpoint by less than the adjustable threshold.
3) Green: Space temperature is between cooling and heating setpoints and space is in Occupied Mode.
4) Gray: Space temperature is between cooling and heating setpoints and space is in Unoccupied Mode.
5) Light blue: Space temperature is below heating setpoint by less than the adjustable threshold.
6) Dark blue: Space temperature is below heating setpoint by more than the adjustable threshold.
7) The initial value of the adjustable threshold shall be 3°F. Threshold shall be adjustable for each zone individually or for all zones together.

d. Display occupancy sensor status for zones with occupancy sensors connected to DDC System or mapped from lighting control system.

3. Ventilation Control Zones:
   a. If Ventilation Control zones are indicated on mechanical plans, provide a separate zone map for Ventilation Control zones.
      1) For zones with a CO₂ sensor, display CO₂ reading and setpoint (PPM), and the value of the CO₂ control loop (%signal). Also indicate CO₂ level graphically by coloring the zone area according to the following scheme:
         a) Red: CO₂ reading is above setpoint for more than 10 minutes.
         b) Green: CO₂ reading is below setpoint.
         c) Blue: CO₂ reading is less than outdoor ambient or 400 PPM if no ambient CO₂ sensor (indicating sensor or measurement problems)
      2) Display zone airflow and airflow setpoint for zones with airflow measurement at the terminal unit.
   b. If Ventilation Control Zones are not indicated as a separate zone type on mechanical plans, display setpoints and current readings for CO₂ and airflow on Thermal Space Control zone map alongside temperature values. In that case, do not apply color coding based on CO₂ level.

4. Radiant Control Zones
   a. If Radiant Control zones are indicated on mechanical plans, provide a separate zone map for Radiant Control zones.
   b. Display the zone temperature (i.e. mass temperature from slab-embedded temperature sensor) and setpoint as numerical values at each zone.
   c. Also indicate zone temperature relative to active (occupied or unoccupied) setpoint graphically by coloring the zone area according to the same scheme used for Thermal Space Control zones (Paragraph 3.7G.2.c).
      1) The initial value of the adjustable threshold shall be 1°F. Threshold shall be adjustable for each zone individually or for all zones together.
   d. For radiant zones, also display current position of hydronic zone control valves and cumulative total number of open/close cycles in the last hour, and in the last 24 hours.
   e. Radiant zone setpoint is typically based on predicted outdoor temperatures plus adjustments (based on air temperatures in overlapping Thermal Space Control zones, and other factors). For each Radiant zone, provide details about how the current setpoint value was determined, including predicted outdoor temperature, any setpoint adjustments, and basis of said adjustments. This information may be provided in a pop-up box or linked page.

5. Lighting Control Zones:
   a. Provide a map of lighting zones overlaid on floor plan for each floor.
b. Lighting status shall be indicated by the following color scheme:
  1) Green: lights on by schedule or occupancy sensor
  2) Yellow: lights on by timed override or virtual switch (e.g. switch-on, auto-off)
  3) Red: lights on by manual override or physical switch
  4) Gray: lights off

c. Display ambient light level in footcandles on graphic for each lighting zone.
d. Display current active dimming level (dimming percentage or number of fixtures on vs off, as appropriate) on graphic for each lighting zone.
e. If lighting zone is subject to demand response load shed, indicate such on graphic.
f. For all zones with occupancy sensors, display the status of the sensor on the zone maps for lighting (duplicating display required for Thermal Space Control, above). This applies to all occupancy sensors, whether connected directly to DDC System or mapped from lighting control system.

6. Color schemes described above shall dynamically update in real time as zone conditions change.

7. Clicking on any zone in any map shall jump to the graphical page for the equipment serving that zone, if any. (Spaces with no associated equipment or sensors shall not provide links.)

8. For each zone participating in a Trim & Respond scheme (see Paragraph 1.4II) to reset airflow/static pressure or supply air temperature, display current number of Requests generated by that zone and the zone's Importance multiplier. Importance multiplier shall be adjustable.

9. For each zone subject to scheduling, provide a link or other means to identify all the schedules that apply to that zone, including the priority of each schedule.

10. If multiple views are necessary to show all areas of a single floor, provide a graphic building key plan that links to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen back to the building key plan and to each of the other graphic floor plan screens for that floor. The key plan view may be combined with the building overview (Paragraph 3.7D.2) so long as each part of the key plan is readily visible and selectable.

H. Equipment Graphics

1. Provide one or more equipment graphics pages for each piece of equipment controlled or monitored by the DDC System.

2. Equipment graphics shall be based on the Contract Drawing control schematics and/or mechanical schematics and details.

3. Animations or color shall be used to indicate on/off status of mechanical components.

4. Position of every valve and damper shall be shown adjacent to the device. Two-position devices may indicate state solely by animation of the graphic element, but all modulating devices shall also indicate commanded position and (if available) position feedback.

5. Hydronic system piping shall be labelled with type of water and also color-coded as follows:
   a. Heating hot water supply: Red
   b. Heating hot water return: Orange
   c. Chilled water supply: Light/bright blue
   d. Chilled water return: Dark blue
   e. Condenser water from tower to chiller: Dark yellow or orange (but distinct from HHWR color)
   f. Condenser water from chiller to tower: Bright yellow
   g. Domestic hot water: Light green
   h. Domestic cold water: Dark green
   i. Greywater: Purple
   j. When there is more than one loop of a given type (e.g. high and low temperature chilled water), they shall be distinguished by labels. Label each type of pipe on every screen where it appears.
6. Flow in hydronic pipes shall be indicated by animation or by the appearance of arrows when flow is present.

7. Each equipment page shall display all physical I/O points and relevant virtual points including setpoints and setpoint reset parameters. See Paragraph 3.7B.
   a. Setpoints and actual point values shall always appear on the equipment page.
   b. For setpoints reset by request-based Trim & Respond logic, also display on the equipment page the current number of Requests and the last action taken by the logic block ("trim", "respond", or "hold").
   c. Provide the ability to view and adjust all setpoint reset parameters (including all parameters used for Trim & Respond logic, where applicable). If space on the equipment page is insufficient, parameters may be viewed and adjusted from linked page or pop-up box.

8. Where multiple Mode-dependent setpoints exist (e.g. chiller with a regular cooling setpoint or reset, and a lower setpoint for dehumidification), all setpoints shall be displayed at all times, with the active setpoint clearly indicated. For example, the active setpoint may be in a bright neutral color while the inactive setpoints are in grey.

9. Complex systems (e.g. chiller and boiler plants) shall have a graphic page for the system as a whole, showing all associated sensors and ancillary equipment. Clicking on any piece of equipment shall open graphic page for that equipment.

10. Pages for terminal units shall include links to the associated air handler and to the floor plan where the zone is located.

11. Pages for terminal units shall also display information about the zone served. Information displayed shall depend on the type of zone; see Paragraphs 3.7G.2 and 3.7G.3, as applicable.

12. Each equipment page shall have a link to open the graphics page for its associated controller. See Paragraph 3.7I.

13. For each piece of equipment generating Trim & Respond reset requests, display current number of Requests generated by that equipment and the equipment’s Importance multiplier. Importance multiplier shall be adjustable. (See Sequences of Operations for explanation of Importance multiplier.)

14. For each piece of equipment subject to scheduling, provide a link or other means to identify all the schedules that apply to that equipment, including the priority of each schedule.

15. On graphics page for each system or subsystem, provide links to display the English-language control sequences and the O&M and submittal information.
   a. Information shall be in a text format that can be searched or copy/pasted to another application. Information shall not be editable from this interface.
   b. Links shall provide this information only for the associated equipment shown on the page, or shall jump to the appropriate bookmark in a longer document.
   c. Linking to the entire sequence or O&M document, without bookmarks, shall not be accepted.

16. For all equipment with runtime alarms specified in Sequences of Operations, show on graphic adjacent to equipment the current runtime, runtime alarm setpoint, alarm light, date of last runtime counter reset, and alarm reset/acknowledge button which resets the runtime counter.

17. For all equipment with lead/lag or lead/standby operation specified in Sequences of Operations, show on graphic adjacent to equipment the current lead/lag order and manual buttons or switches to allow manual switching of lead device by the operator.

I. Controller and Network Device Graphics
   1. Provide a graphic page for each controller, gateway and networked device in DDC System.
   2. Controller graphics shall consist of an image of the physical networked device and its connected points.
Page shall display all physical input and output points, with point names, current values, and override status shown.

Point information shall be displayed adjacent to or otherwise associated with the actual physical point connection on the device.

Each point shall display any configured BACnet Events/alarms.

Clicking on any point shall open the BACnet properties and override page (Paragraph 3.7B.7) for that point.

3. Graphics pages shall provide physical location of controller, and also display MAC address, network number, Device Identifier Object Property, and Device Object Name Property. See Paragraph 3.9C.

4. Graphics pages for gateways shall display the gateway interoperability schedule. See Paragraph 3.9D.

5. Each controller graphics page shall include links back to the equipment graphics page(s) for the equipment controlled by the device.

J. Summary Pages

1. Summary pages shall be text-based tables that provide key information about listed equipment.

2. Summary pages shall be linked from pages that represent individual examples of the device being summarized (e.g. each VAV box graphic shall have a link to a summary of VAV boxes).

3. Each summary shall display information about one type of equipment or zone. All equipment of that type (e.g. all AHUs, all VAV boxes, etc) shall appear in a given summary.

4. Each summary shall occupy a single graphical page. If there are more items than will fit in a single screen, provide means to scroll through the page so that all items can be viewed.

5. Each line of a summary shall link back to page for the equipment or zone it summarizes.

6. Provide a summary page for all equipment of each type, including but not limited to the following equipment and information (as applicable/available):

a. Air handlers: operating mode; on/off status; supply air temperature; supply air temperature setpoint; fan speed; duct static pressure; duct static pressure setpoint; damper positions; coil valve positions; outdoor airflow; supply airflow.
   1) If setpoints are reset by Trim & Respond logic (see Paragraph 1.4II), also include: total reset Requests received, separately for each type of Request
   2) If unit generates Trim & Respond Requests to reset plant setpoints, also include the following, separately for each type of Request: total reset Requests generated; cumulative %Request-Hours; Importance multiplier

b. Single-zone air handlers and fancoils: As for air handlers, plus zone temperature, zone temperature setpoint; CO₂ level (PPM); CO₂ control loop value (%signal).

c. Radiant Control zones: Zone (mass) temperature; zone (mass) temperature setpoint; hydronic zone control valve position; cumulative total number of valve open/close cycles in the last hour, and in the last 24 hours.

d. Thermal Space Control zones: Airflow; airflow setpoint; damper position; discharge air temperature; coil valve position; zone temperature; zone temperature setpoint; occupancy sensor status.
   1) If unit generates Trim & Respond Requests to reset air handler setpoints, also include the following, separately for each type of Request: total reset Requests generated; cumulative %Request-Hours; Importance multiplier

e. Ventilation Control zones: Airflow, airflow setpoint, damper position; CO₂ level (PPM); CO₂ control loop value (%signal); occupancy sensor status
1) If unit generates Trim & Respond Requests to reset air handler static pressure setpoint, also include: total reset Requests generated; cumulative %Request-Hours; Importance multiplier

f. If Ventilation zones are not distinct from Thermal Space Control zones, provide a single zone summary page including information from both zone types above.

7. Provide a summary page for each Zone Group (Paragraph 3.6F.2.a).
8. Provide a summary page for each group of equipment (Paragraph 3.6F.2.c).
9. Provide a summary page that lists all points currently overridden through the DDC System. Each item on list shall link back to the page associated with the overridden point.

K. Schedules

1. Support all scheduling functions required by Paragraph 2.8G.
2. Provide interface to create, edit, delete and view binary, analog and multistate BACnet Schedule objects and parameters.
3. Hierarchical Schedules: The system shall allow operators to define schedules in terms of systems of related equipment.
4. Group Schedules: The system shall allow operators to apply any schedule to any group, as defined in Paragraphs 2.4C.4 and 3.6F.
5. User shall be able to apply priority level to any schedule.
6. Conflicting schedules shall be resolved as follows
   a. First, the schedule with the highest priority shall prevail.
   b. If conflicting schedules have equal priority, the schedule with the smallest scope (i.e. fewest zones, or fewest devices) shall prevail.
7. Provide at least the following schedule views for any object or set of objects:
   a. Daily view showing all scheduled transitions, including start and end times and transition action, in a timeline or date-keeper format.
   b. Views showing all scheduled transitions for the calendar week, for the calendar month, and for the next 30 days. Transition indications may be abbreviated in these views. Clicking on a day shall bring up the daily view with full details of the scheduled transitions.
   c. Schedule summary: Show normal versus holiday versus override schedules, and the net operating schedule that results from all contributing schedules.

L. Alarms and Events

1. Alarms shall be displayed on the interface graphics for the system that the alarm is associated with (e.g. a fan alarm shall be shown on the graphic of its associated air handler).
   a. Display brief description of alarm (e.g. “failure to run”, “low pressure”, etc.) next to image of device or sensor status/output.
   b. Alarm notice and device status/output text shall appear in color based on alarm condition, per Paragraph 3.7A.2.
2. When there are unacknowledged alarms, a lamp or icon indicating this shall be displayed at the interface.
   a. This indicator shall be clearly visible but not obtrusive, and shall not cover other interface elements.
   b. This indicator shall flash for critical alarms.
3. Each new alarm shall appear in the log of current alarms
   a. Alarms shall be recorded in the log with at least the following information:
      1) Date and time of the alarm
2) Level of the alarm
3) Source of alarm
4) Description of the alarm
5) Equipment tags for devices in alarm
6) Possible causes of the alarm, if provided by the fault detection routines (see Sequence of Operations)

b. Operator shall be able to acknowledge or reset alarms from the alarm log screen. Alarms may be acknowledged in batches, except for Level 1 alarms.
c. When alarms are acknowledged (or time out), they shall be removed from the current alarm log and stored permanently in the alarm history log, recording time of acknowledgement and identity of the acknowledging operator.
d. Operator shall be able to view all current and historical alarms from any location in the internetwork.
e. Operator shall be able to sort alarms based on level, time/date, and current status within both the current and the historical alarm logs.
f. Alarm logs shall be able to be exported as a spreadsheet or CSV formatted file.

3.8 DATA ARCHIVE SERVER INSTALLATION

A. General
1. Install Data Archive Server in location shown on Contract Drawing mechanical plans.
2. Connect to UPS per Paragraph 2.15D. Configure to automatically shut down server before UPS is depleted and notify building engineer via email, and automatically restart server when power is restored.
3. Install and configure software as required by Paragraph 2.6D.
4. Configure external hard drive (Paragraph 2.6C.3) for automatic backup of Data Archive Server boot drive.
   a. Configure Windows Backup to perform incremental backup of boot drive once per day.
   b. Backup shall provide the ability to quickly and easily restore the entire boot drive and resume operation in the event of drive failure.
   c. Other equivalent means of backup are acceptable, if coordinated with Owner's IT. If backup is provided by Owner's IT infrastructure, DDC Contractor shall provide written proof of coordination.
5. Store on Data drive a complete copy of DDC System databases, user screens, graphics, setpoints, settings and all other data necessary to recover from complete loss of system programming. See Paragraph 1.9B.3

3.9 CONTROL INTERNETWORK INSTALLATION AND CONFIGURATION

A. General
1. BACnet network numbers and Device Object IDs shall be unique throughout the internetwork.
2. If the DDC System provided under this Section is to integrate with an existing building control network, DDC Contractor shall coordinate assignment of network numbers and Device Object IDs with the Owner or facility staff to ensure that no duplicate network numbers or device IDs occur.
B. Network Resilience

1. Interruption or fault at any point on the Supervisory Control Network or Primary Controller LAN shall not interrupt communications between other nodes on the network.
2. If a network is severed, two separate networks shall automatically be formed and communications within each network shall continue uninterrupted.
3. The system shall automatically monitor the operation of all network devices and annunciate any device that goes off-line because it is failing to communicate.

C. Network Device Naming Convention

1. MAC Address:
   a. Every network device shall have an assigned and documented MAC address unique to its network.
   b. Ethernet Networks: Document MAC address assigned at its creation.
   c. MS/TP networks: Assign from 00 to 64.

2. Network Numbering:
   a. Assign as BBBFF, where:
      1) BBB = 1-655 assigned to each building
      2) FF = 00 for building backbone network, 1-35 indicating floors or separate systems in the building.
   b. Provide ability to change network number through device switches or operator interface.

3. Device Object Identifier Property Number:
   a. Assign as XXFFBBB, where:
      1) XX = number 0 to 40
      2) FF = 00 for building backbone network, 1-35 indicating floors or separate systems in the building
      3) BBB = 1-655 assigned to each building.
   b. Provide to change device instance number by device switches or operator interface.

4. Device Object Name Property Text:
   a. For each device, assign unique device name using BACnet Object Name property.
   b. Names shall be a plain English description of function, device type, and service location. Example "B001 HHW Primary Pump P-3".
   c. If the device appears on an equipment schedule, include the scheduled equipment tag in the device name.

D. Gateways

1. Connect hardwired and networked points as indicated on Contract Drawing control schematics. Make hardwired connections for points shown as hardwired, even if the same point is available through the gateway.
2. DDC Contractor must coordinate in advance all details of the installation, configuration and interface for all gateway devices. See Paragraph 3.4E.
3. Provide backup copy of all programming and parameters for all gateways, including interoperability schedule, as part of the Project data archive (see Paragraph 1.9B.3).
4. Plant-level equipment shall be connected at a Primary control network. All other equipment may be connected to a Secondary control network.
3.10 DDC CONTROLLER INSTALLATION

A. Physical Installation

1. Controllers and associated devices shall be assembled into panels or enclosures by DDC Contractor in a workshop environment, per Paragraph 3.1B.
2. Install controllers in enclosures as required by field conditions and this Section.
3. Install all controllers in readily accessible location per Paragraph 3.5L.
4. Install controllers such that they can be quickly and easily disconnected from the network.
5. For every controller, provide a dedicated power switch if the controller does not include one built in.
6. Connect controllers to power such that both the control component and the equipment are powered from the same panel.
7. Connect controllers to a power source of equal reliability (normal, emergency, uninterruptable, etc.) to the power source of the equipment being controlled.
8. HVAC systems and equipment served by a backup power source or UPS shall have associated DDC system products that control such systems and equipment also served from a backup power source or UPS.
9. Connect sensors, actuators and other attachments such that they can be quickly and easily disconnected for service. All wiring connections shall be made to field-removable, modular terminal strips.

B. Functional Installation

1. Each controller shall be installed and configured to permit standalone operation without requiring other network devices to execute local control strategies. See Paragraphs 1.2C, 2.8D, and 2.8E.3.
2. Configure DDC System to share data between networked controllers and other network devices.
   a. Point information from any controller (including BCs, AACs, and ASCs) and from any gateway shall be capable of being used in a control sequence in any other panel.
   b. The use of a computer or another DDC device as a communications server between control panels and/or gateways is not acceptable.
3. Each individual mechanical system or piece of equipment shall be controlled by no more than one controller with sufficient capacity to be connected to all field devices and sensors associated with that system and/or piece of equipment.
   a. All points associated with and common to one unit or other complete system or equipment shall reside within a single controller (including I/O expander boards as allowed below). Point data which may be transmitted over the LAN are limited to the following exceptions:
      1) Global points such as outdoor air temperature.
      2) Requests sent from zones to systems or systems to plant, used to trigger equipment operation or reset setpoints.
      3) Mode information sent from zones to systems or systems to plant, used to select or change operating logic.
      4) Notwithstanding these exceptions, all operations required to maintain a controlled variable at setpoint must still be performed entirely within a single controller.
   b. Sensors used to measure error between a controlled variable and a setpoint shall always be hardwired directly to the controller, even if the sensor is physically remote from the controller (e.g. an end-of-loop differential pressure sensor). Transmitting the sensor signal to the controller over the LAN is not acceptable.
   c. Control of a single piece of mechanical equipment performed by or distributed among multiple controllers, even within the same cabinet, is not acceptable.
4. Configure controllers for automatic safe restart after a loss of power:
   a. If programming is intact, the controller shall resume full operation without operator intervention. All monitored functions shall be updated.
   b. If battery backup has been exhausted or programming is lost for any reason, the controller shall automatically report this condition and prepare to receive a download over the network.
   c. The controller shall automatically reset its clock such that time dependent functions occur on schedule without a manual reset.
   d. The DDC Contractor shall pre-configure staggered start such that the startup surge or inrush current of each major piece of equipment (air handling unit, boiler plant, chiller plant, etc.) has time to resolve before the next start event.

C. Point Structure and Naming

   1. The following applies to all physical I/O points, virtual points, and application program parameters.
   2. Points shall be named and identified in a completely consistent and rigorous fashion throughout the DDC System.
      a. Consistency shall extend to capitalization, use of separator characters, etc. For example, points named AHU-1.ReturnAirTemp and Ahu2.return_air_temp in the same Project would not be acceptable.
   3. Point Naming Convention
      a. DDC Contractor may name points according to the standards established by Project Haystack, or shall use the alternate convention described in the next paragraph.
   4. Point Naming Convention – Alternate
      a. Name every point with the following format:
      b. The use of another separator character, other than period ("."), in point names is acceptable as long as it consistently applied throughout.

<table>
<thead>
<tr>
<th>Building Number</th>
<th>Category</th>
<th>System</th>
<th>Equipment Tag (from equipment schedules)</th>
<th>Component</th>
<th>Property</th>
<th>Typical units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELCT</td>
<td>Lighting</td>
<td>Plug</td>
<td>SWITCH PHOTO</td>
<td>Command</td>
<td>On/off</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Generator</td>
<td>CB</td>
<td>Status</td>
<td>On/off</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Misc</td>
<td>CWS</td>
<td>Light</td>
<td>Footcandles</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Airhandling</td>
<td>CWR</td>
<td>Power</td>
<td>Watts</td>
<td></td>
</tr>
<tr>
<td>HVAC</td>
<td></td>
<td>Exhaust</td>
<td>HHWS</td>
<td>Voltage</td>
<td>Volts</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heatplant</td>
<td>HHWR</td>
<td>Current</td>
<td>Amps</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coolplant</td>
<td>CHWS</td>
<td>ValvePos</td>
<td>%open</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Misc</td>
<td>CHWR</td>
<td>DamperPos</td>
<td>%open</td>
<td></td>
</tr>
<tr>
<td>PLMB</td>
<td>Domwater</td>
<td>Domwater</td>
<td>OA</td>
<td>Temperature</td>
<td>°F</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Air</td>
<td>Air</td>
<td>SA</td>
<td>Humidity</td>
<td>%RH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natgas</td>
<td>Natgas</td>
<td>RA</td>
<td>Pressure</td>
<td>Psig, “H2O”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N2</td>
<td>N2</td>
<td>EA</td>
<td>Flow</td>
<td>Cfm, gpm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>O2</td>
<td>O2</td>
<td>GAS</td>
<td>Energy</td>
<td>Btu</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Irrigation</td>
<td>Irrigation</td>
<td>FLUID</td>
<td>Speed</td>
<td>%, Hz</td>
<td></td>
</tr>
<tr>
<td>MISC</td>
<td>Weather</td>
<td>Weather</td>
<td></td>
<td>Signal</td>
<td>%</td>
<td></td>
</tr>
</tbody>
</table>
c. Example: Heating hot water supply temperature from Boiler 1 in Building 1 would be named 001.HVAC.Heatplant.B-1.HHWS.Temperature
d. Suggested additions to and deviations from the point naming convention shall be submitted for review and approval by the Engineer of Record.

D. Point Summary Table

1. DDC Contractor shall provide a Point Summary Table which shall serve as the master list of all physical points for the Project.
2. Table shall include the following information:
   a. Building identification (number or name) if more than one in Project
   b. System type
   c. Equipment type
   d. Point suffix
   e. Full point name (see Point Naming Convention above)
   f. Point description
   g. Ethernet backbone network number
   h. Network number
   i. Device ID
   j. Device MAC address
   k. Object ID (object type, instance number)
   l. Engineering units
   m. Device make and model number
   n. For sensors, range of device
   o. Device physical location description if applicable. Include floor and column line intersection to one decimal place (e.g. line 6.2 and line A.3).

3. Provide a Point Summary Table on each shop drawing schematic, for the points associated to that schematic only.
4. Also provide a Master Point Summary Table in electronic format as a single Excel spreadsheet listing all physical points in the Project.
   a. Each parameter listed above shall be a separate column heading, such that it is possible to filter or sort by any point parameter.
   b. Submit digital version of Point Summary Table with Submittal Package 1.

5. DDC Contractor shall provide Point Summary Table (with updates as required) to the Commissioning Authority as a reference and guide during the commissioning process.
6. DDC Contractor shall maintain Point Summary Table current and up-to-date throughout the duration of the Project.
7. Project closeout documents shall include an accurate as-built Point Summary Table.

E. Point Programming

1. Connect and configure I/O points for all points shown on Contract Drawing control schematics
   a. Points indicated on control schematics as hardwired must be connected as hardwired points
   b. Points indicated as networked may be hardwired or networked, at the option of the DDC Contractor, unless otherwise indicated on control schematics.

3. Set up and configure trends for all points per Paragraph 3.6E.
4. Provide templates customized for point type, to support efficient input of individual point information in a standardized format using standard BACnet Objects, including long-name field.

5. Program at least the following information for each analog input point:
   a. Name
   b. Address
   c. Scanning frequency or COV threshold
   d. Engineering units
   e. Offset calibration and scaling factor for engineering units
   f. High and low signal bounds (reasonableness values), which shall prevent control logic from using shorted or open circuit values
   g. Default value to be used when the actual measured value is not reporting or is out of bounds
   h. Alarms as specified in Sequence of Operations.
   i. Selectable averaging function that shall average the measured value over a user defined number of scans for reporting

6. Program at least the following information for each analog output point:
   a. Name
   b. Address
   c. Output updating frequency
   d. Engineering units
   e. Offset calibration and scaling factor for engineering units
   f. Output range
   g. Default value to be used when normal control logic is unavailable
   h. For VFD minimum speed command, program as described in Paragraph 3.10G.

7. Program at least the following information for each binary input point:
   a. Name
   b. Address
   c. Engineering units (on/off, open/closed, freeze/normal, etc.)
   d. Debounce time delay
   e. Alarms as specified in Sequence of Operations.
   f. Runtime logging and totalization, per Paragraph 2.8L
   g. For equipment status, set ON/OFF signal threshold as described in Paragraph 3.10F.

8. Program at least the following information for each binary output point:
   a. Name
   b. Address
   c. Output updating frequency
   d. Engineering units (on/off, open/closed, freeze/normal, etc.)
   e. Minimum on-time
   f. Minimum off-time
   g. Runtime logging and totalization, per Paragraph 2.8L
   h. Default value to be used when normal control logic is unavailable

9. Each point associated with a hardware device, sensor or instrument shall have its BACnet long-name point description field filled out with the following information:
   a. Device manufacturer
   b. Device model number
   c. Description of point function
   d. For sensors, range
   e. For space sensors, room number where the sensor is located
10. All hardware and software points, including all physical inputs and outputs, shall be able to be overridden by the operator as required by Paragraph 2.2F.1.

F. Equipment Status Binary Input Threshold Adjustment
   1. Current switch sensing status of fan with discharge damper: Fan status is OFF when fan discharge damper is fully closed.
   2. Current switch sensing status of fan with belt-driven fan: Fan status is OFF when fan belt is broken.
   3. Current switch sensing status of pump: Pump status is OFF when pump is dead headed.
   4. For differential pressure sensor used as a flow switch: Pump status is ON when all valves are open (i.e. pump is out on its curve).

G. Variable Frequency Drive (VFD) Programming
   1. The speed analog output sent to VFDs shall be configured such that 0% speed corresponds to 0 Hz and 100% speed corresponds to maximum speed configured in the VFD.
   2. Speed signal shall scale linearly from 0% to 100%. For example, if the maximum speed is 80Hz (as is the case with some fan arrays), then a 50% speed command signal would correspond to device speed of 40Hz.
   3. For each piece of equipment, the minimum speed shall be stored in a single BMS software point. This value shall be written to the VFD’s minimum speed setpoint via the drive’s network interface. In the case of a hard-wired VFD interface, the minimum speed shall be the lowest speed command sent to the drive by the BMS.
   4. Determine minimum speed as specified in Paragraph 3.16C.8.

H. Loop Tuning
   1. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot.
   2. A loop shall be deemed stable if, within 3 minutes after being perturbed while in normal operation, it returns to setpoint within tolerances listed in Paragraph 2.2D.2.
   3. Record tuning parameters and response test results for each control loop in the Pre-Functional Test report.

3.11 ENCLOSURES

A. Installation of Enclosures
   1. Install all control devices and accessories in specified enclosures (see Paragraph 2.14A), with products installed as required by Paragraph 2.14B.
   2. Install each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
   3. Do not house more than one controller in a single enclosure. Exception: Controllers for different parts of the same mechanical plant (e.g. controllers for pumps, cooling tower, and chiller) may be housed together in the same enclosure provided all other requirements of this Section are met.
   4. Unless otherwise directed by the AHJ, all enclosures shall be located such that visual observation and adjustment can be accomplished while standing flatfooted on the floor in a convenient location adjacent to the equipment served. Install all equipment in readily accessible location per Paragraph 3.5L.
   5. Attach wall-mounted enclosures to wall using steel struts that are hot dipped galvanized or epoxy-coated for corrosion resistance. Install plastic caps on exposed cut edges of strut.
   6. To the extent practical, align adjacent enclosures horizontally for a neat and workmanlike appearance.

8. Provide permanent identification tags for enclosure, and for control products within enclosure, per Article 3.12.

B. Wiring of Enclosures

1. Interconnections between internal termination points and face and/or panel-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped.

2. Provide insulated, modular, feed-through, clamp-style recessed captive screw-type terminal blocks suitable for rail-mounting with end plates and partitions for the termination of all field wiring in temperature control panels. Terminals for field connections shall be UL-Listed for 600 volt service, individually identified per control drawings with adequate clearance for field connections.
   a. Prewire all controller input and output points (including spare points) to terminal blocks, such that field wiring connections are made at the terminal block rather than on the controller.
   b. Field wiring to equipment with integral terminals and/or unitary equipment shall not be required to have terminal blocks.

3. All high-voltage wiring consistent with the definitions of NEC Class 1 and all low-voltage wiring consistent with the definitions of NEC Class 2 must be strictly separated by barriers, raceways or sub-panels according to the requirements of the NEC Chapter 7 Article 725.

4. Label each end of cable, wire and tubing in enclosure per Article 3.12.

5. Provide enclosure with a line-voltage nominal 20 amp GFCI duplex receptacle for service and testing tools.
   a. Wire receptacle on hot side of enclosure disconnect switch and include with a 5 amp circuit breaker.
   b. Where multiple enclosures are installed in close proximity, only one receptacle is required per six feet of wall.
   c. Label enclosure to indicate presence of service outlet.

6. Provide each enclosure with a surge suppressor, electrical disconnect, control fuse, and control transformer sized as required by the application.


D. Documentation: Provide as required by Paragraph 3.12B.4.b.

3.12 IDENTIFICATION

A. General

1. Manufacturers’ nameplates and UL or CSA labels to be visible and legible after equipment is installed.

2. Identifiers shall match that shown on submitted and approved control shop drawings or Contract Drawing control schematics or schedule.

3. All plug-in components shall be labeled such that removal of the component does not remove the label.

B. Equipment and Devices

1. General
a. Nameplates and tags shall be black lettering on white background. White lettering on black background is not acceptable (hard to read in dark, dirty conditions).

2. Valve actuators, damper actuators and sensors:
   a. Provide minimum 1 inch high laminated white phenolic nameplate with engraved or raised black lettering, ½ inch high.
   b. Indicate device function (for example “Return Air Damper” or “CHW Supply Temp”).
   c. Include device tag, matching submitted shop drawings.
   d. Permanently affix on or immediately adjacent to device. Valve actuators may be hung with metal chain. Do not attach with wire.

3. Controllers and control products:
   a. Provide minimum 1 inch high laminated white phenolic nameplate with engraved or raised black lettering, ½ inch high.
   b. Indicate controller identification (matching shop drawings) or control product function, and equipment being controlled.
   c. Permanently affix on or immediately adjacent to controller (on removable backplane if inside an enclosure).
   d. If control product is installed in an enclosure, provide tags on the control products and duplicate tags on front of enclosure so that enclosure contents may be easily identified.

4. Panels and Enclosures
   a. Provide 2 inch high laminated white phenolic nameplate with engraved or raised black lettering, 1 inch high. Permanently affix to exterior of enclosure.
      1) Indicate panel identifier and service.
      2) Indicate the electrical panel and circuit number from which enclosure is powered.
   b. Provide permanent documentation for each enclosure, including the following:
      1) A complete set of as-built schematics, tubing, and wiring diagrams and product literature applicable to control products in that enclosure. Install documentation in a pocket on inside of door. (For enclosures with windows, attach pocket to interior bottom of enclosure.)
      2) A points list for all points in enclosure on laminated card, permanently affixed or chained to interior of enclosure so that it cannot be lost.

5. Building pressure pickups
   a. Each space pressure sensor pickup (e.g. for building pressure, or reference for duct static pressure) shall be colored so as to contrast with the pickup mounting surface, and shall be labelled indicating its service and purpose.
   b. Pickups in occupied spaces, this identification shall be visible but discrete: Pickup indicator shall be no more than ½ inch in diameter, and label shall be no more than 1/2 inch high with ½ inch high text.
   c. Pickups in unoccupied or back-of-house spaces shall be clearly visible: Pickups indicator shall be at least 1 inch in diameter, and label shall be at least 1 inch high with ½ inch high text.

6. Terminal units:
   a. Provide 2 inch high laminated white phenolic nameplate with engraved or raised black lettering, 1 inch high indicating device tag.
      1) For units above drop ceilings, permanently affix to bottom of terminal unit such that it is visible from below with a ceiling tile removed.
2) For units above a hard ceiling, permanently affix to side of terminal unit such that it is visible from nearest access hatch.

7. Identify room sensors and thermostats related to terminal boxes or valves by indicating associated device with indelible marker on sensor body hidden by cover.

C. Wiring and Tubing

1. Provide self-laminating, self-adhesive typed labels. Marker pen, including indelible marker, is not acceptable. Hand-written labels are not acceptable.
2. Permanently label or code each point of field terminal strips to show the instrument or item served.
3. All wiring, cabling and tubing, including that within factory fabricated panels, shall be labeled at each end within 2 inches of termination.
   a. Label shall indicate origination and destination devices.
   b. Power wire labels shall include service, voltage, and breaker source.
   c. Communication wire labels shall include the BAS address, BACnet object instance, or termination number.
   d. Sensor and signal wire labels, and pneumatic tubing labels, shall include device function being sensed (e.g. "CHW Supply Temp") or controlled (e.g. "Return Air Damper"). Label text shall match nameplate used at sensor or control device.
4. Labels shall be applied at field I/O connection and at all intermediate connections throughout length to controller connection.

3.13 POWER WIRING INSTALLATION

A. The selection and installation of line and low-voltage power wiring and wiring connections, including subpanels, conduit and raceways, required for Work in this Section shall be provided by the DDC Contractor except as specifically indicated on Division 26 Drawings.

1. Review electrical drawings and panel schedules for panel locations and quantity of extra circuits available for controls power.
   a. Use circuits specifically marked as “for controls” first.
   b. Circuits marked “spare” may be used if no “for controls” circuits are available but do not use all available “spare” circuits. In all cases leave minimum two “spare” circuits in each panel.
2. Extend power to all DDC devices, including 120V power, from an acceptable power panel.
3. Coordinate with Division 26 during shop drawing development for final connection location.

B. General requirements for obtaining power include the following:

1. Electrical service to controls panels and control devices shall be provided by isolated circuits, with no other loads attached to the circuit, clearly marked at its source. The location of the breaker shall be clearly identified in each panel served by it.
2. Obtain power from a source that feeds the equipment being controlled such that both the control component and the equipment are powered from the same panel. Where equipment is powered from a 460V source, obtain power from the electrically most proximate 120V source fed from a common origin.
3. Where control devices are located in or on new equipment, coordinate with the equipment manufacturer and feed the control with the same source as the equipment. If the equipment’s control transformer is large enough and of the correct voltage to supply the controls, it may be used. If the equipment’s control transformer is not large enough or not of the correct voltage to supply the controls, provide separate transformer(s).
4. Controllers shall use separate power transformers from those used by actuators and other end devices that use half wave rectification.
   a. Exception: Zone level controllers and actuators may share a common power transformer.

5. Unless transformers are provided with equipment, DDC Contractor shall provide transformers for all low voltage control devices including terminal units. Transformer(s) shall be located in control panels in readily accessible locations.

C. Emergency, Uninterruptible, and Backup Power

1. Where a controller controls multiple systems on varying levels of power reliability (normal, emergency, or uninterruptible/backed-up), the controller shall be powered by the highest level of reliability served.
2. See Paragraph 2.2J for additional requirements.
3. See Paragraph 2.15D for UPS device requirements.

D. Work shall comply with NEC with all state and local amendments, all provisions of the NEC including articles 210 and 310, and all requirements of Division 26 Specification for power wiring.

1. All high voltage wiring shall meet the requirements of NEC Class 1.
2. All low-voltage wiring shall meet the requirements of NEC Class 2 and shall be sub-fused as required to comply with current limits.
3. Run wiring in raceway or conduit as required by codes and Specifications.
4. Do not run power wiring and signal or communication wiring in the same raceway or conduit, regardless of voltages.

E. Maximum allowable voltage for wiring to control products shall be 120V. If only higher voltages are available, provide step-down transformers at connection to power source.

F. All field wiring shall be properly labeled at each end per Paragraph 3.12C.

G. The DDC Contractor shall verify integrity of all wiring to ensure continuity and freedom from shorts and grounds after the installation is complete.

H. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component.

3.14 CONTROL AND COMMUNICATION WIRING INSTALLATION

A. General

1. Wiring and raceways for control communications and signaling shall be sized, selected and provided by the DDC Systems Contractor.
2. Provide dedicated wiring for signal transmission between sensors, actuators, controllers, routers, gateways, and local and remote peripherals.
3. Power-line communication is not acceptable.
4. All control communication and signal wiring shall be installed as continuous lengths, if that length is commercially available. When required, terminal blocks in junction boxes shall be used to join wire lengths. There shall be no wire-to-wire splices between termination points.
5. Terminate all control and/or interlock wiring.
6. All work shall comply with NEC requirements, Divisions 26 and 27, and all local codes and requirements of the AHJ.
   a. All high voltage wiring used for control shall meet the requirements of NEC Class 1.
1) Control wiring shall not exceed 120V.

b. All low-voltage wiring shall meet the requirements of NEC Class 2. Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.

1) Some low-voltage wiring may be run outside of conduit per Paragraph 3.14B.2.

B. DDC Contractor shall protect control and communication wiring from physical damage and electrical or RF noise.

1. Install wiring in UL listed raceway or conduit when located in unconcealed or inaccessible locations, locations where wires may be damaged including equipment rooms, or as required by code or AHJ.

2. Low voltage control communication and signal wiring may be installed without conduit or raceway in concealed, protected, and accessible locations (such as above suspended ceiling) if noise immunity is ensured. Cables shall be UL listed for the specific application or installation location (e.g. ceiling plenums).

3. Do not install communication or signal wiring in raceway or enclosures containing high- or low-voltage power wiring. Junction boxes, enclosures and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays, transformers, CTs, etc.).

4. Run direct current signal wires separately from alternating current conductors. Where allowed by code, AC and DC wiring routes shall only cross at a 90 degree angle.

5. DDC Contractor is fully responsible for noise immunity and for cost to rewire in conduit if electrical or RF noise affects performance.

C. All wiring shall be installed in a neat and workmanlike manner. Follow all manufacturers’ installation recommendations.

1. Wiring not in conduit shall be installed as follows:
   a. Routed parallel or perpendicular to building and/or mechanical lines.
   b. Supported by or anchored as follows. Do not lay wiring on the ceiling.
      1) Wire that is not used for Ethernet, TCP/IP, or BACnet IP networking may be secured to structural members or to supports for ductwork, piping, and raceways.
      2) Wire that is used for Ethernet, TCP/IP, or BACnet IP networking (i.e. “category” cable) shall be supported from below by J-hooks, trays, or similar means. Do not kink or twist category cabling, and do not zip-tie it to its supports.
   c. Neatly tied at 5 foot intervals and at least 1 foot above ceiling tiles and light fixtures.
   d. Installed in sleeves where it passes through walls and floors. Maintain fire, smoke, envelope and pressure ratings of each space.

2. All wire and cable installed in ceiling return plenums must be rated for plenum installation. If uncertain, contractor shall assume that above-ceiling spaces are plenums.

3. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

4. All wire-to-device connections shall be made at a terminal block or terminal strip.

5. All wire to wire connections for power shall be at a terminal block. Communication wire shall be continuous, with no wire-to-wire connections.

D. Shielding

1. Maintain continuous shielding of all communications and signal wiring.

2. Shields shall be grounded only at controller or power source end and floated at other end, unless otherwise recommended by the controller manufacturer.

3. Float shields through termination points, maintaining only on single grounding point and insulating from ground at all other points.
E. Network Wiring

1. All MS/TP network wiring shall be installed in accordance with the requirements and methods specified in Chapter 9.2 of the BACnet standard.
2. All BACnet/IP network wiring shall be installed in accordance with the requirements of ANSI/TIA-568.
3. All networks (main and sub-networks) shall utilize network diagnostic devices if available. Network diagnostic devices shall be installed per manufacturer’s instructions.

F. Raceways and Conduit

1. DDC Contractor is responsible for sizing and selection of raceways and conduits in accordance with code and Division 26 and 27 Specifications.
2. Raceway must be rigidly installed, adequately supported per code, properly reamed at both ends, and left clean and free of obstructions. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
3. Conceal all raceways, except within mechanical, electrical, or service rooms.
4. Install raceway to maintain a minimum clearance of 6 inches from high-temperature equipment.
5. Raceway Sections shall be joined with couplings per code.
6. Terminate with fittings at boxes. Install insulated bushings on all raceway ends not terminating in boxes. Seal top end of all vertical raceways.
7. Flexible metal raceways and conduit shall not exceed 3 feet in length and shall be supported at each end.
   a. Flexible metal raceway less than ½ inches electrical trade size shall not be used.
   b. In areas exposed to moisture liquid-tight, flexible metal raceways shall be used.
8. Include one pull string in each conduit 1 inch or larger.

G. Identification

1. Use color-coded conductors consistently throughout the entire DDC System installation.
2. All field wiring shall be properly labeled at each end per Paragraph 3.12C.
3. Color code each junction box cover plate to indicate wiring type using enamel paint, as follows:
   a. Green = low-voltage signal wiring
   b. Yellow = line-voltage signal wiring
   c. Blue = pneumatic tubing
   d. Power wiring does not require markings.

H. Equipment Failsafe: Wire binary outputs to either the normally-closed or normally-open contacts depending on desired action in case of system failure.

1. Unless otherwise indicated in Contract Drawings or Specification, wire to disable equipment in event of system failure.
2. Exception: The following shall be wired to enable in the event of system failure.
   a. Hot water pumps
   b. Coil recirculation pumps provided for freeze protection

I. Hardwire Interlocks: Provide as described below and shown on Contract Drawing control schematics to ensure equipment shutdown occurs even in the event of control system failure. The use of software interlocks alone is not acceptable

1. Hardwire device NC contact to equipment starter upstream of HOA switch, or to VFD enable contact.
2. Where multiple pieces of equipment are controlled by a device without sufficient contacts, provide a relay at the device for the required number of contacts.
3. Provide hardwire interlock for the following devices where indicated on Contract Drawing control schematics or in Sequences of Operations:
   a. Duct smoke detector
   b. Fire alarm system contact
   c. High discharge static pressure
   d. Low mixing plenum pressure
   e. Freeze-stats
   f. Cooling tower vibration switch

J. Maintain updated as-built wiring diagrams with terminations identified at the jobsite.

K. The DDC Contractor shall verify integrity of all wiring to ensure continuity and freedom from shorts and grounds after the installation is complete. Communication wiring shall be tested to verify noise immunity and signal-to-noise ratio.

3.15 CONTROL AIR TUBING INSTALLATION

A. General
1. Pneumatic tubing shall be sized by the DDC Contractor.
2. All control air piping shall be installed in a neat and workmanlike manner parallel to building lines with adequate support.
3. Piping above suspended ceilings shall be supported from or anchored to structural members. Tubing shall not be supported by or anchored to electrical raceways or ceiling support systems.
4. Pneumatic tubing shall not be run in raceway containing electrical wiring.
5. All pneumatic tubing shall be concealed except in equipment rooms or unfinished areas.

B. Installation methods and materials
1. Concealed and inaccessible: Use hard or soft copper tubing, or FR plastic in metal raceway. Room thermostat drops in stud walls in areas with lay in ceiling may be FR plastic tubing.
2. Concealed and accessible (including ceiling return air plenums): Use hard or soft copper tubing or FR plastic tubing, subject to the following limitations
   a. FR tubing shall be enclosed in metal raceway when required by local code.
   b. Quantity of FR tubing per cubic foot of plenum space shall not exceed manufacturer’s published data for Class 1 installation.
3. Exposed to view or damage: Use hard drawn copper. FR plastic in metal raceway is acceptable where environment is within temperature limits of plastic tubing.
   a. Where copper tubing is used, a section 12 inches or less of FR plastic tubing is acceptable at final connection to control device.
4. Serving fire or fire-smoke dampers: Use hard copper tubing for mains and exposed piping. Use hard or soft copper tubing for branches and concealed piping.
5. Inside panels: Use plastic tubing.
7. Plastic tubing: No concealed splices. Continuous runs through concealed areas.
8. Copper tubing: Use only tool-made bends.
C. Fittings and Sleeves
   1. Where FR tubing exits the end of raceway or junction box, provide a snap-in nylon bushing. Where FR tubing exits control panels, provide bulkhead fittings.
   2. Where copper tubing exits junction boxes or panels, provide bulkhead fittings.
   3. Brass-barbed fittings shall be used at copper-to-FR tubing junctions. Plastic slipped over copper tubing is not acceptable.
   4. Sleeve through concrete surfaces in minimum 1 inch sleeves, extended 6 inches above floors and 1 inch below bottom surface of slabs.

D. Number-code or color-code tubing at each end for identification and servicing of control system. Code shall be as indicated on approved shop drawings.

E. Provide cartridge-type desiccant dryers for air lines passing through outside air stream or through unheated spaces where temperatures are below 30°F.

F. Testing and Commissioning:
   1. Make test on sectional piping during progress of installation to ensure no leakage.
   2. Test entire piping system by placing it under 20 PSI pressure for 24 hours. Trend log pressure during test and submit test results with Pre-Functional Test Report.

3.16 TESTING AND COMMISSIONING

A. General
   1. Perform tasks in the order outlined in Paragraph 3.1D, subject to direction of the General Contractor.
      a. Notify the Commissioning Authority and the Engineer if jobsite circumstances, Project schedule, or General Contractor instructions require substantial deviation from this sequence of events.
   2. Comply with Commissioning Requirements as specified in Division 1.
      a. DDC Contractor shall provide a qualified technician who shall execute all Pre-Functional and Functional Tests in the presence of the Commissioning Authority.
      b. All deficiencies identified shall be corrected and demonstrated to the Commissioning Authority after resolution for acceptance.
      c. DDC Contractor shall fulfill all obligations as outlined in the Commissioning Plan including post occupancy/Warranty testing as deemed necessary by the Commissioning Authority.
   3. Coordinate with Work specified in Sections 23 08 00 and 26 08 00.
   4. Unless specifically prohibited by Owner, DDC Contractor shall provide remote access to DDC System for duration of commissioning process.
      a. DDC Contractor shall set up a Commissioning User account with read-only access, including the ability to view all graphical pages and view and download trends.
      b. Provide account login credentials to Engineer of Record and Commissioning Authority.
      c. Establish and verify account access prior to performing Functional Tests.

B. Test Forms
   1. Pre-Functional/Point-to-Point Test Forms
      a. DDC Contractor shall prepare forms to verify correct installation and document proper startup of the DDC System and its components.
b. Provide forms for all checks and tests described in Paragraph 3.16C.
c. Each form shall be typewritten and have a header or footer where the technician performing the test can indicate his/her name and the date of the test.

2. Test and Balance forms shall be provided by Test and Balance (TAB) Contractor. However, Setpoint Determination Report is the joint responsibility of TAB Contractor and DDC Contractor. In accordance with Paragraph 3.4F, DDC Contractor shall coordinate with TAB Contractor and submit a coordination plan including a copy of the TAB forms to be used in setpoint determination.

3. Functional Test procedures and associated forms shall be prepared by Commissioning Authority
   a. DDC Contractor shall review Functional Test requirements in Paragraph 3.16E to understand the scope and level of effort required for the testing process.
   b. Functional Tests procedures and associated forms shall be provided to DDC Contractor, after Submittal Package 2 has been reviewed and accepted.
   c. DDC Contractor shall review tests and provide comments as follows:
      1) If any proposed testing procedure risks damaging equipment or voiding equipment warranty, provide suggested alternative test procedure to avoid these concerns.
      2) Recommend changes that will improve ease, accuracy or speed of testing.
      3) Verify that proposed test procedures will generate the expected responses when tested against the specified Sequences of Operations. Identify any discrepancies between the apparent intent of the Sequences of Operations and the apparent intent of the associated test procedure.
   d. Provide comments in digital format per Paragraph 1.8E. Preferred format is Microsoft Word documents with Track Changes enabled.

4. DDC Contractor shall prepare Functional Tests procedures and associated forms, after Submittal Package 2 has been reviewed and accepted.
   a. DDC Contractor shall prepare forms to verify correct execution of Sequences of Operations logic and correct operation of all alarms, interlocks, and schedules without compromising system integrity or damaging any piece of equipment.
   b. Provide forms for all checks and tests described in Paragraph 3.16E.
   c. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.

5. Submit forms for approval in Submittal Package 3 (Testing Forms) per Paragraph 1.8H.4.
6. All forms shall be provided in digital format per Paragraph 1.8E.

C. Pre-Functional and Point-to-Point Tests

1. General Checks
   a. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
   b. Ensure devices are properly installed with adequate clearance for maintenance.
   c. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in raceway.
   d. Verify that all sensor locations are as indicated on drawings and are away from heat sources and other causes of erratic operation.

2. Electrical Checks
   a. Verify integrity/safety of all electrical connections.
   b. Power to all controllers and actuators. Confirm emergency or uninterruptible power where specified.
   c. Verify that shielded cables are grounded only at one end.
d. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
e. Check power supplies for proper voltage ranges and loading.
f. Ensure that terminations are safe, secure and labeled in accordance with Article 3.12.
g. Check for adequate grounding of all panels and devices.

3. For each controller serving central plant or central air handling equipment, and for a sampling of 20% of all other controllers selected by CxA or Engineer of Record, perform the following tests:

   a. Network Resilience
      1) Disconnect controller from Primary Control LAN.
      2) Verify the event is annunciated at operator’s interface and recorded in event log.
      3) Verify that the controlling LAN reconfigures per Paragraph 2.3C.2.d.

   b. Standalone Operation
      1) Disconnect controller from Primary or Secondary Control LAN.
      2) Verify the event is annunciated at operator’s interface and recorded in event log.
      3) Verify that isolated controllers continue to perform normally per Paragraph 2.2E.

   c. Loss of Power
      1) Disconnect controller from power source. Wait for 30 seconds, then reconnect power.
      2) Verify that controller configuration and programming is retained, and that controllers resume function automatically, per Paragraph 2.8S

4. For each individual point on each individual controller (i.e. 100% testing), perform Point Verifications and Point-to-Point Tests. **Note that all connected points on every controllers must be tested. Testing only a sample of controllers is not acceptable for point-to-point tests.**

   a. Binary Outputs:
      1) Verify proper installation
      2) Verify correct normal position
      3) Verify correct response to command including parity of response (i.e. verify that a command OFF turns equipment off and not on).

   b. Binary Inputs:
      1) Verify proper installation
      2) Verify signal from device maps to correct signal at graphical interface.
      3) Verify input signal thresholds are correct per Paragraph 3.10F.

   c. Analog Outputs
      1) Verify proper installation
      2) Verify correct normal position.
         a) Test all fail-safe actuators by disconnecting power and verifying direction of travel.
      3) Verify correct response to command including direction of movement.
      4) Verify correct start and span (maximum and minimum stroke)
a) Verify that all automatic valves and dampers close completely upon a closed command. Adjust valve stem and damper blade travel as required.
b) Verify/adjust output range for points sending commands (e.g. setpoint) to other equipment.
d) Analog Inputs
   1) Verify installation of sensors.
   2) Verify correct signal and mapping at graphical interface.
   3) Calibrate sensors that require field calibration, if any, per points lists on Contract Drawing control schematics.
      a) Calibration shall be performed using instruments that meet the requirements of Paragraph 1.6D.
      b) Adjust calibrating parameters in software (such as slope and intercept) as required.
      c) A calibration log shall be kept and initialed by the technician indicating date and time, sensor and hand-held readings, and calibration constant adjustments and included in the Pre-functional Test Report.
      d) Inaccurate sensors must be replaced if calibration is not possible.

5. Control Loops
   a. Verify that all control loops are tuned for stability and fast response per Paragraph 3.10H, to meet the requirements of Paragraph 2.2D.
   b. For all loops, document P/I gains, tuning parameters, chosen setpoints, time delays, and loop execution speed in Pre-Functional Test report.

6. Network Communication Tests
   a. Verify adequate signal strength on all networks.
   b. Verify that network wire runs do not exceed maximum length.
   c. Verify a maximum of 32 full-load nodes and 64 devices total per MS/TP network, per Paragraph 2.3B.6.
   d. With all system and communications operating normally, perform the following network response tests.
      1) Tests shall be performed after trends per Paragraph 3.6E have been set up and are operational.
      2) Alarm annunciation test
         a) Randomly select a device whose failure will generate a Level 1 or 2 alarm and manually shut it off.
         b) The status points for the device must indicate the change of state of the device at the Operator Workstation within 10 seconds per Paragraph 2.2B.3.
         c) The test shall be repeated for four devices in each building.
      3) Clock synchronization test
         a) Randomly select a controller on a Secondary Control LAN.
         b) Compare that controller's clock signal to the system clock.
         c) Test passes if sampled time signal is within 2 seconds of system clock time.
         d) Test 5% of devices on Secondary Control LANs, minimum of three devices.
4) If the system fails any test, the system architecture shall be revised as required. Provide additional capacity (install more trend memory, more controllers with trend storage capability, network repeaters to allow an increase in network speed, etc.) and repeat tests.

7. Alarms and Interlocks
   a. Test each software alarm separately. Record date and time, alarm description, action taken or signal value sent to initiate the alarm, and observed response.
      1) Verify alarm levels are correct per Sequences of Operations and this Section.
      2) Confirm that each alarm is annunciated correctly per Paragraphs 3.7L.1 and 3.7L.1.
      3) Confirm that each alarm is routed to appropriate devices and individuals per Paragraph 3.6I.4.
   b. Test each hardware interlock separately.
      1) Trip interlock using field (physical) contacts.
      2) Verify appropriate equipment response including normal position of fail-safe actuators. Note position of each fail-safe actuator separately on test forms.
   c. Coordinate with Division 26 to test fire and life safety systems alarm contacts and interlocks.

8. VFD Minimum Speed
   a. DDC Contractor is responsible for determining the minimum speed for each variable frequency drive (VFD).
   b. Unless otherwise indicated, minimum speed for VFD-driven fans and pumps shall be the greater of 10% or the minimum required for visible motion.
      1) As described Sequences of Operations, minimum speed for some equipment may be related to a flow setpoint or maintaining minimum flow. For that equipment, the minimum speed shall not be higher (though it may be lower) than the speed required to maintain the minimum flow setpoint.
   c. Determine the minimum speed as follows:
      1) Start the fan or pump.
      2) Manually set speed to 6 Hz (10%) unless otherwise indicated in Sequences of Operations. For cooling towers with gear boxes, use 20% or whatever minimum speed is recommended by tower manufacturer.
      3) Observe fan/pump in field to ensure it is visibly rotating.
      4) If not, gradually increase speed until rotation is observed.
      5) The speed at this point shall be the minimum speed setpoint for this piece of equipment.
      6) Record minimum speeds in log and store in software point.
   d. Minimum speed shall be established independently for each piece of equipment. Exception: For multiple pieces of identical equipment used for identical applications, the results of one test may be applied to all.
   e. Note that for fans and pumps, there is no minimum speed required for motor cooling. Power drops with cube of speed, causing motor heating to be minimal at low speeds.
   f. This work shall be done only after fan/pump system is fully installed and operational.
   g. Program VFD minimum speeds in accordance with Paragraph 3.10G.

9. User Interface Checks
   a. All user interface elements and graphics are functional.
   b. Graphics are properly bound to physical devices or virtual points.
   c. Links and page jumps are functional and logical.
d. Point information updates in a timely fashion as required by Paragraph 2.2B.2.
e. Events and alarms are annunciated timely as required by Paragraph 2.2B.3.

10. Pre-Functional Test Report
   a. After submitted test forms have been accepted, DDC Contractor shall perform all
      listed tests, take corrective action as required for failed tests, and repeat tests until a
      passing condition is obtained.
   b. Document results on forms and submit for approval as Pre-Functional Test report.
   c. Pre-Functional Tests including in particular point-to-point tests (Paragraph 3.16C.4)
      must be performed and documented for every individual point in the system. Testing
      a sample or subset of points shall not be acceptable. The Pre-Functional Test report
      shall not be accepted, nor shall further work be authorized, until all point-to-point
      tests have been completed to the satisfaction of the Engineer of Record and
      Commissioning Authority.
   d. Report shall be word-searchable electronic format per Paragraph 1.8E. All
      information on forms shall be typed. Hand-written forms, or typed forms with
      hand-written results, shall not be acceptable.

D. Test and Balance
   1. Coordinate with Work performed under Division 23 Test and Balance (TAB). DDC
      Contractor shall support TAB Contractor per Paragraphs 3.4F and 3.4J in execution of tests
      that require interaction with or overrides of the DDC System.
   2. Calibration Software
      a. Software shall be provided to TAB Contractor free of charge on at least a temporary
         basis to allow calibration of terminal box airflow controls and other Work specified
         under Division 23 TAB.
      b. DDC Contractor shall loan TAB Contractor a POT or portable device with software
         installed for the duration of Work specified under Division 23 TAB.
      c. Provide sufficient training to those performing Work specified under Division 23 TAB
         to allow them to use the software for balancing and airflow calibration purposes.
         Contractor shall provide a single training session for this purpose.
   3. Setpoint Determination
      a. Perform Pre-Functional Tests described in Paragraph 3.16B before performing
         setpoint determination.
      b. DDC Contractor shall provide a list of setpoints and other parameters to be
         determined by the TAB Contractor. TAB Contractor shall develop Setpoint
         Determination Plan to establish correct values for these parameters. DDC Contractor
         shall review Setpoint Determination Plan to ensure that planned tests will provide
         information required to correctly program Sequences of Operations. DDC Contractor
         shall submit Setpoint Determination Plan. See Paragraph 3.4F.
      c. DDC Contractor shall submit Setpoint Determination Report, which shall consist of
         the relevant subset of Test and Balance forms, documenting results of all tests and
         final setpoints determined. DDC Contractor shall use these values for initial BAS
         programming.
         1) In Setpoint Determination Report, DDC Contractor shall flag any values that
            seem anomalous, outside of expected range, or otherwise problematic.
         2) Submit report for approval before scheduling Functional Tests.

E. Functional Tests
   1. Functional Tests shall test all control logic in a formal manner to verify that Sequences of
      Operation were programmed accurately and provide the intended system behavior.
2. If Functional Test procedures are prepared by others, DDC Contractor shall review tests and provide comments as follows:
   a. If any proposed testing procedure risks damaging equipment or voiding equipment warranty, provide suggested alternative test procedure to avoid these concerns.
   b. Recommend changes that will improve ease, accuracy or speed of testing.
   c. Verify that proposed test procedures will generate the expected responses when tested against the specified Sequences of Operations. Identify any discrepancies between the apparent intent of the Sequences of Operations and the apparent intent of the associated test procedure.

3. Functional Test report shall not be performed until all required trend logs (Paragraph 3.6E) are set up and recording, and read-only remote access via the Commissioning User login account is available (Paragraph 3.16A.4). Functional Tests performed in the absence of trends shall not be accepted.

4. Each functional test shall consist of a series of defined steps.
   a. For each step, test form shall include descriptions of an action/override to initiate the step and the expected system response.
   b. For each step, technician performing test shall record actual system response and any notes or comments.
   c. Expected response and actual response shall be described qualitatively (e.g. “fan speed increases”) or quantitatively (e.g. “setpoint increases by 1.5°F”) as appropriate.
   d. Technician shall describe all observed responses. Where quantitative results are expected, technician shall record specific values observed. Simply checking “OK” or “PASSED” shall not be sufficient.

5. Functional tests shall verify at least the following, with additional tests as required by Commissioning Authority:
   1) Equipment and occupancy schedules: Override system clock to verify equipment starts and stops on appropriate times/days.
   2) Equipment startup dependencies, sequencing (e.g. verify that HHW pump starts before boiler fires), and lockouts (e.g. verify that boiler will not fire if HHW pump is disabled): Override status points of triggering equipment and verify response of dependent equipment.
   3) Minimum on- and off-times: Override runtime counters and trigger events and verify that equipment remains running or remains stopped for appropriate period of time.
   4) Lead/lag staging: Override staging triggers (e.g. temperature readings, T&R Requests, calculated loads, etc.) and verify automatic start of lag equipment.
   5) Lead/standby staging: With system operating, disable lead equipment and verify that standby equipment starts automatically.
   6) Rotation: Override runtime counters and verify that lead device rotates as intended.
   7) All setpoint reset logic: Override resetting parameter (e.g. outdoor air temperature) and verify correct reset of setpoint.
   8) For all Trim & Respond (see Paragraph 1.4II) setpoint reset loops:
      a) Request generation: Override conditions at source of Requests (e.g. terminal unit or air handler) to verify that correct quantity and type of Request is generated. Verify that Requests are removed when override is removed.
      b) Setpoint reset: Override number of Requests seen by controlled equipment (e.g. air handler or plant) and verify correct reset of setpoint. Adjust number of responses to observe trimming, responding and holding of setpoint.
c) Setpoint reset range: By adjusting Requests at controlled equipment, cause Trim & Respond loop to cycle setpoint from minimum value to maximum and then back to minimum. Confirm that loop does not get “stuck” at either end of setpoint range.

9) Correct handling of all failure conditions, including equipment failover and alarm notification: Override equipment to produce failure conditions and observe system response.

6. Testing schedule shall be coordinated with the Commissioning Authority and/or Commissioning Coordinator.

7. Functional tests may be witnessed by Owner’s Representative at the Owner’s option.

8. All accepted Functional Tests shall be conducted by the DDC Contractor with results confirmed and signed by the Contractor’s technician.

   a. After submitted test forms have been accepted, DDC Contractor shall perform all listed tests, take corrective action as required for failed tests, and repeat tests until a passing condition is obtained.
   b. Document results on forms and submit for approval as Functional Test report.
   c. All Functional Tests must be documented as passing and Functional Test report must be accepted by the Engineer of Record and Commissioning Authority before Demonstration Tests are scheduled. **Tests which are noted as passing but fail during demonstration shall incur additional costs to DDC Contractor, above and beyond cost of remediating failed test.** See Paragraph 3.16H.5.
   d. Report shall be word-searchable electronic format per Paragraph 1.8E. All information on forms shall be typed. Hand-written forms, or typed forms with hand-written results, shall not be acceptable.

F. Demonstration Tests

1. Demonstration tests consist of representative sample of Pre-Functional Tests randomly selected by the Commissioning Authority, and (potentially all) Functional Tests as chosen by the Commissioning Authority.

2. Schedule the demonstration with the Commissioning Authority and Owner’s Representative at least 1 week in advance.

3. Demonstration Tests shall not be scheduled until the Functional Test report has been accepted.

4. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc.

5. Contractor-supplied personnel shall be those who conducted the Functional tests or who are otherwise competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems.

6. The system will be demonstrated following procedures that are the same or similar to those used in the Pre-Functional and Functional Tests. The Commissioning Authority will supply the test forms at the site at the start of the tests.

7. Demonstration tests shall be witnessed by CxA. Demonstration tests undertaken without CxA shall not be considered valid.

8. Demonstration tests may be witnessed by Engineer of Record at the EOR’s option.

9. Demonstration tests may be witnessed by Owner’s Representative at the Owner’s option.

10. Contractor shall conduct tests as directed by and in the presence of the Commissioning Authority and complete test forms. Completed forms shall be submitted as the Demonstration Test report to the Commissioning Authority after tests are complete.

11. Demonstration Tests shall be successfully completed and accepted prior to Substantial Completion.
G. Trend Reviews
   1. Trends shall be fully configured to record and store data per Paragraph 3.6E.
   2. Post-Construction Trend Test
      a. Provide table of points to be trended along with trend basis. Submit for review and
         approval by the by Commissioning Authority a minimum of 14 days prior to start of
         Trend Period.
      b. Collect data for three-week Trend Period. Trend Period shall not commence until
         Demonstration Tests have been successfully completed and accepted.
      c. At end of Trend Period, DDC Contractor shall review data to verify that system is
         operating correctly. Identify system faults. Perform remedial work as required and
         verify correction with no less than 3 days additional trends.
      d. Export data to spreadsheet (XLS or CSV format) for review.
         1) Data shall be provided as a single electronic file
         2) Organize data into tabs, with one tab for each individual system or major piece
            of equipment.
         3) First tab shall be a table of contents indicating the equipment or devices
            associated with each tab. Identify equipment using tags from Contract Drawing
            equipment schedules.
         4) Second tab shall summarize data anomalies and system faults. Provide graph
            of data for each incident. Summarize identified issues and what if any remedial
            work was performed.
         5) Provide additional post-remediation trends on separate tabs.
      e. Provide data to Owner and Commissioning Authority. Data will be analyzed by
         Commissioning Authority.
      f. DDC System shall be accepted only if third-party analysis of trend data indicates
         proper system operation without malfunction, without alarm caused by control action
         or device failure, and with smooth and stable control of systems and equipment in
         conformance with this and related Sections.
      g. Perform additional remedial work as directed by Commissioning Authority or
         Engineer of Record and provide proof-of-correction trends as required.
   3. End-of-Warranty Trend Test
      a. No more than 60 days before end of Warranty Period, DDC Contractor shall export
         all trend data from start of Post-Construction Trend Period.
      b. Provide data to Commissioning Authority in spreadsheet form as described above.
      c. DDC System shall be accepted and Warranty Period considered complete only if the
         trend review indicates proper system operation without malfunction, without alarm
         caused by control action or device failure, and with smooth and stable control of
         systems and equipment in conformance with this and related Sections.
      d. Perform additional remedial work as directed by Commissioning Authority and
         provide proof-of-correction trends as required.

H. Remedial Work
   1. Repair or replace defective Work, as directed by Owner’s Representative in writing, at no
      additional cost to the Owner.
   2. Restore or replace damaged Work due to tests as directed by Owner’s Representative in
      writing, at no additional cost to the Owner.
   3. Restore or replace damaged Work of others, due to tests, as directed by Owner’s
      Representative in writing, at no additional cost to the Owner.
   4. Remedial Work identified by site reviews, review of submittals, demonstration test, trend
      reviews, etc. shall be performed to the satisfaction of the Owner’s Representative, at no
      additional cost to the Owner.
5. Contractor shall compensate Owner’s Representatives, Commissioning Authority, and/or Engineer of Record on a time and material basis at standard billing rates for any additional time required to witness additional demonstration tests or to review additional BAS trends beyond the initial tests, at no additional cost to the Owner.

3.17 TRAINING

A. Coordinate schedule and materials with Owner and Commissioning Authority.

B. Provide preliminary training as required such that operating staff can respond to occupant needs and other operating requirements during start-up and commissioning phase.

C. Formal Training

1. Training shall be conducted after all commissioning is complete and systems are fully operational. Training shall not start until Functional Testing is complete and the Functional Test Report has been submitted and accepted.

2. Provide training sessions for personnel as required by Owner.

3. Training Schedule

   a. Schedule training to provide Owner with at least 10 business days advance notice.

   b. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays.

   c. Training shall be scheduled within 30 days of the completion (including acceptance) of Functional testing, unless otherwise authorized by the Owner.

   d. All training sessions shall occur within a four week period.

   e. Each complete training session shall occur on a different day, to facilitate maximum attendance. Schedule training sessions as required to accommodate Owner’s needs.

4. Attendance Tracking

   a. Request from Owner in advance of training a proposed attendee list with name, phone number and e-mail address.

   b. Provide a preprinted sign-in sheet for each training session with proposed attendees listed and blank spaces to add additional attendees. Participant tracking can also be performed electronically.

      1) Include training session number, date and time, instructor name, phone number and e-mail address, and brief description of content to be covered during session.

      2) List attendees with columns for name, phone number, e-mail address and a column for attendee signature or initials.

   c. Circulate sign-in sheet at beginning of each session and solicit attendees to sign/initial.

   d. At end of each training day, send Owner and Commissioning Authority e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet or equivalent digital participant record for each session.

5. On-Site Training

   a. Include additional 40 hours total of on-site training to assist personnel in becoming familiar with site-specific issues, systems, Sequences of Operations, etc.

   b. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
c. Instructor shall provide training materials, Projector and other audiovisual equipment used in training.
d. Training shall be provided by factory-trained instructors experienced in presenting this material. DDC Contractor staff may provide training, if so qualified.
e. Training may be in non-contiguous days at the request of the Owner.

D. Training Content and Levels

1. Operators are divided into three levels of expertise and shall receive training including but not limited to the tasks listed for each training level.

2. DDC Contractor shall provide training for personnel in numbers and at levels requested by Owner. Coordinate with Owner and Commissioning Authority.
a. At a minimum plan to train 2 Regular Operators, 1 Advanced Operator, and 1 System Administrator.

3. Regular Operators shall be trained to perform the following tasks:
   a. Proficiently operate the system
   b. Understand control system architecture and configuration
   c. Understand BAS system components
   d. Understand system operation and Sequences of Operations
   e. Operate the workstation and peripherals
   f. Log on and off the system
   g. Access graphics, point reports, and logs
   h. Adjust and change system set points, time schedules, and holiday schedules
   i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
   j. Understand and acknowledge alarms
   k. Understand system drawings, and Operation and Maintenance manual
   l. Understand the Project layout and location of control components
   m. Print point and predefined reports

4. Advanced Operators shall be trained as Regular Operators plus the following tasks:
   a. Make and change graphics on the workstation
   b. Create, delete, and modify alarms, including annunciation and routing
   c. Create, delete, and modify point trend logs, and graph or print these both on an ad-hoc basis and at user-definable time intervals
   d. Create, delete, and modify reports
   e. Add, remove, and modify system’s physical points
   f. Create, modify, and delete programming
   g. Add control panels
   h. Add Operator Workstations
   i. Create, delete, and modify system displays — both graphical and otherwise
   j. Perform BAS system field checkout procedures
   k. Perform BAS controller unit operation and maintenance procedures
   l. Perform workstation and peripheral operation and maintenance procedures
   m. Perform BAS system diagnostic procedures
   n. Configure hardware including PC boards, switches, communication, and I/O points
   o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware
   p. Adjust, calibrate, and replace system components
   q. Maintain software and prepare backups

5. System Administrators shall be trained as Regular Operators plus the following tasks:
   a. Maintain software and prepare backups
   b. Create and print custom reports, including tenant billing summaries
   c. Interface with Project-specific, third-party operator software
d. Add new users and understand password security procedures

E. Training Materials

1. Provide each attendee with a color hard copy of all training materials and visual presentations.
2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.
4. Additionally, store an electronic copy of training materials and training videos (if applicable) on Data Archive Server (if provided) and Operators Portable Workstation.
5. Training materials shall include step-by-step instructions (including illustrations, screen captures, etc.) for how to perform all task identified in Paragraph 3.17D such that a new operator, who has not attended the training in person and has minimal familiarity with this DDC System, can easily follow the instructions and successfully perform all of the identified tasks.

F. Video of Training Sessions:

1. Trainer shall provide or arrange for a digital video and audio recording of each training session. Create a separate recording file for each session.
2. Stamp each recording file with training session number, session name and date.
3. Provide Owner with two copies of digital files on DVDs or flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

G. During the warranty period, provide unlimited live support for all trained operators. DDC Contractor or DDC System Manufacturer shall provide a direct customer support channel for user questions and feedback, preferably as a message or chat application native to the Operator’s Interface.

END OF SECTION
SECTION 255005 – LABORATORY MONITORING AND CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the contract, including general and supplemental conditions, and Division 01 sections apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
   1. Laboratory Monitoring and Control System
      a. Laboratory fume hood face velocity monitoring and controls.

1.2 RELATED SECTIONS

A. Division 8 – Doors and Windows
B. Section 115313 – Laboratory Fume Hoods and Other Air Containment Units
C. Section 233600 – Air Terminal Units
D. Section 255000 – Building Automation Hardware and Networking
E. Section 253000—Building Automation Sensors and Control Devices
F. Division 01 Section “General Requirements”
G. Division 01 Section “Special Procedures”

1.3 SYSTEM DESCRIPTION

A. Lab Airflow Control System
   1. The intent of this Specification is to define the hardware and control requirements for the laboratory airflow control system (LACS). The system specified shall be based on variable fume hood exhaust volume with sash position reset control of fume hoods, synchronization of supply and exhaust airflows, and control of lab room temperature via reheat coils and airflow reset. The BAS shall integrate to the LACS through BACnet® interface directly from room control panels.
   2. Low-pressure drop laboratory airflow control valves including supply and exhaust valves as listed in schedule and on drawings per specification 233600.
3. Integral electronic pressure independent controller with standard “Native BACnet” interface for lab air valves.
4. Associated room control panels for laboratory airflow control system including supply and exhaust valves as listed in schedule and on drawings.
5. All associated room and duct temperature sensors as required for laboratory airflow control system spaces.
6. Fume hood controllers, sash sensors and monitors as required for laboratory airflow control system spaces. Fume hoods per Division 11.

1.4 SUBMITTALS

A. Comply with Division 01, Section “General Requirements” and Division 23, Section “Common Results for HVAC”, review of materials.
B. Follow requirements of Section 255000 - Building Automation Hardware and Networking.
C. Minimizing energy consumption is of primary importance in the system design; therefore any airflow control valve considered for this project must be submitted with test data showing the Minimum Operating Pressure of the valve as tested in accordance with ANSI/ASHRAE STD 130 Paragraph 5.3. The submitted test data must be in the form of an xy plot, with the y axis representing differential pressure measured across the fully opened valve and the x axis representing airflow volume measured through the fully opened valve. The test data for each size valve must include the entire published operating range of the valve.
D. Literature for submitted valve must show both a curve and spreadsheet of minimum operating pressure drop versus CFM throughout its operating range.
E. Operation and Maintenance Data:
   1. Submit operation and maintenance data under provisions of Division 01 Section “General Requirements” Paragraph 1.8.H “Operation and Maintenance Data”
   2. The LACS supplier shall provide a full documentation package to the Owner on completion of the project. Documentation shall include as-built drawings, device lists, and controller configuration lists for each controller.

1.5 WARRANTY

1. At the successful completion of the final testing, commissioning, and demonstration phase in accordance with the terms of this Specification, if equipment and systems are operating satisfactorily to the Owner and if all completion requirements per Paragraph 1.9 have been fulfilled, the Owner shall certify in writing that the DDC System has been accepted. The date of acceptance shall be the start of the warranty period.
2. Guarantee all materials, equipment, apparatus and workmanship (including programming) to be free of defective materials and faulty workmanship for at least the following periods from date of acceptance:
   a. Controllers (BCs, AACs, and ASCs), routers and gateways: five years
   b. Valve and damper actuators: five years
c. Temperature, humidity, and CO2 sensors: five years
d. Programming: one year
e. All else: one year

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS – LABORATORY MONITORING AND CONTROL SYSTEMS

A. Accutrol LACS
B. Or equal.

2.2 BUILDING AUTOMATION SYSTEM COMPATIBILITY

A. The BAS shall integrate to the LACS through BACnet® interface directly from room control panels.

2.3 FUME HOOD FACE VELOCITY MONITORING AND CONTROL SYSTEM

A. The fume hood controller(s) function as stand-alone units, modulating the hood exhaust valves as required via the factory-mounted electronic high speed actuators. The fume hood controller has a local display which includes visual and audible alarm indicators. The fume hood controller will be capable of communicating read points indicating the calculated face velocity (fpm), face velocity set point (fpm), exhaust volume (CFM), sash position (% open), alarm status, DI status and emergency status to the BAS via BACnet MS/TP communications protocol.

B. The fume hood controller shall be a BTL listed device. The fume hood controllers will be capable of providing the local (BAS) room controller with two mutually independent discrete analog outputs configured for either (face velocity, exhaust volume, sash position, or valve position) with the following signal types available; 0-10v, 2-10v, 0-5v, 1-5v, 0-20mA or 4-20mA. Fume hood alarms will be hardwired from the fume hood controller alarm relay output to the local (BAS) controller. The occupied/unoccupied room status will be communicated via a hard wired digital input to each of the fume hoods in a given lab/room.

C. Display
   1. The fume hood display provides the average face velocity value with alarm and emergency purge LEDs
   2. The local display includes a mini USB port for connecting the PC with the fume hood controller configuration software. All configurable fume hood control and alarm parameters can be accessed and modified using the pc-based user interface software

D. Sash Sensor
   1. Fume hood sash sensors shall measure position of sash via electrical sensor cable and calculate sash area based on that measured position. The sensor shall be designed to be mounted to the fume hood sash counter-weight cable system. Face velocity controller
shall be capable of supporting up to three vertically-moving sashes, with each sash connected to a vertical sash sensor.

2.4 ROOM LEVEL CONTROLLERS

1. Controller shall be programmable and capable of achieving sequences described in 25 90 00 Sequences of Operation
2. The controller shall be provided with a dual ARM processor and a built-in web server, with 16 Mbyte NOR Flash and 64 Mbyte SDRAM. The controller shall support BACnet and Modbus. The room level controller shall be powered by 24V AC/DC Power.
3. The controller shall be provided with a minimum of 30 input and output (IO) points which comprise of 8 digital inputs, 8 universal inputs, 8 digital outputs, 2 open collector outputs and 4 analog outputs. The controller shall be also be provided with an Ethernet port and 2 RS485 ports.
4. The controller shall be fully configurable via a lap-top computer or a PC utilizing a user-friendly Graphic User Interface software package. Display of current readings of all flows, outputs, tuning values, setpoints, and status values shall be available through this interface. Entry of control setpoints, and scaling and tuning constants shall also be provided by this interface.
5. Power voltage requirements for the controllers shall be 24V AC/DC. Power can be provided by individual or centralized power transformers, provided by the installing contractor.
6. The Controller shall have inputs and outputs per controls schematics.

PART 3 - EXECUTION

3.1 HOLD AND INSPECTION

A. Refer to provisions of Division 01 Section “Special Procedures” for hold points for inspection, witnessing testing, etc.

3.2 FUME HOOD VELOCITY CONTROLLER SYSTEM INSTALLATION

A. Start-up shall be performed by a factory-authorized representative.

B. The adjustable parameters within the fume hood velocity controller shall be tuned to maintain the setpoint of 110 fpm +10 fpm. The low alarm shall be set to 80 fpm and the high alarm shall be set to 150 fpm. The display averaging period shall be set for 5 seconds. The alarms shall be set to unlatch in the event that air velocity returns to normal.

1. Set initial alarm resume setting to 5 minutes.
C. Program minimum flow set point to maintain 25 CFM / square foot of work surface at the fume hood. As fume hood sash is lowered, ensure this minimum flow rate is maintained. This setting will override the face velocity set point at low sash positions. This may result in the average velocity exceeding the set point value, resulting in high alarm condition.

3.3 PROGRAMMING

A. Controllers shall be programmed per 25 90 00 Sequences of Operation

3.4 MAINTENANCE AND OPERATING AND TRAINING INSTRUCTION

A. See Division 01, Section “General Requirements”.

END OF SECTION
SECTION 259000 - BUILDING AUTOMATION SEQUENCES OF OPERATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section provides logic sequences of operations for a Direct Digital Control of building systems, subsystems, and equipment by a Building Automation System provided in accordance with the Related Specifications.

B. Explanatory Notes

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01, apply to this Section, except as specifically noted in this Section.

B. Related Specifications:
   1. Section 23 00 00 “HVAC General Requirements”
   2. Section 23 05 93 “Testing, Adjusting and Balancing for HVAC”
   3. Section 25 30 00 “Building Automation Instrumentation and Control Devices”
   4. Section 25 50 00 “Building Automation Hardware and Networking”

C. Electronic Version Available
   1. To facilitate the Work under this Section, a searchable digital version of this document will be provided to the DDC Contractor upon request to the Engineer of Record.
   2. Digital version includes live hyperlinked cross-references, such that clicking “see Paragraph XX” will jump to Paragraph XX.
   3. Digital version is formatted with PDF “bookmarks” corresponding to the outline levels of the document, as an aid to navigation.
   4. DDC Contractor is strongly encouraged to request this digital version if it is not provided through standard channels. The sequence logic may be challenging to follow in “dead tree” format.

1.3 DEFINITIONS

A. Industry Standard Definitions
   1. Analog Input (AI): Proportional input signal (typically 0-10 VDC or 4-20 mA) to BAS.
   2. Analog Output (AO): Proportional command signal (typically 0-10 VDC or 4-20 mA) from BAS.
   3. Binary Input (BI): On/off output input signal or contact closure to BAS.
   4. Binary Output (BO): On/off output command signal or contact closure from BAS.
   5. BAS: Building Automation System. Equivalent to Energy Management and Control System (EMCS), Building Management System (BAS), etc.
   6. DDC: Direct digital control, the control of building equipment by a programmable computer.
B. Definitions Particular to this Specification

1. Enabled/Disabled (for equipment): Indicates whether a piece of equipment is available to respond to a command (to run, or modulate, etc.) The statement "X is enabled" means that X is available to run but not necessarily running.

2. Enabled/Disabled (for control loops): Indicates whether the control loop is actively calculating an error signal and is available to use for control. Disabled control loops are inactive; they do not accumulate error and they are not used for control. See also Paragraphs 1.1A.1.a through 1.1A.1.a.

3. Mode: The dominant Operating Mode of an air handling unit (e.g. Occupied, Unoccupied, Warm-up, etc.) Often scheduled but may be in response to building conditions. See Paragraphs 3.3C.6 and 3.3H.8.a.

4. Occupied/Unoccupied: Refers to a zone (or collection of zones) that is scheduled for potential occupancy (or not). People may or may not be present.

5. Populated/Unpopulated: Refers to a zone where people are currently present (or not), as indicated by occupancy sensor, CO2 measurement, or other means. Note that Populated/Unpopulated status is independent of and unrelated to Occupied/Unoccupied status, which is a function of schedule.

6. Request-based Trim & Respond logic: A reset scheme that periodically resets the setpoint at an "upstream" system (e.g. air handler) using demand-based Requests from "downstream" devices (e.g. terminal units), adjusting the setpoint at defined time-step frequency. For more detail and a worked example, see Paragraph 3.3A.14.

7. Zone/Control Zone: A defined indoor area that is controlled to maintain specified temperature and/or airflow.
   a. Thermal Control Zone (aka "thermal zone" or simply "zone"): An indoor space (i.e. room or part thereof) in which the air temperature is controlled to a setpoint based on temperature measurement by a thermostat or space sensor. Outdoor air ventilation is also provided for regularly occupied spaces. Thermal control and ventilation may be provided by separate devices (e.g. radiant panel plus DOAS terminal unit) or by a single device (e.g. VAV-reheat terminal unit).

C. Also see "Definitions" in Part 1 of Section 25 50 00.

1.4 SUBMITTALS

A. General

1. See "Submittals" in Part 1 of Section 25 50 00 for complete DDC Building Automation System submittal requirements, submittal process, schedule of submittals, and required submittal format.

2. The remainder of this document focuses on submittal requirements specifically related to the software and sequences. Additionally, all submittals described in Section 25 50 00 are mandatory.

3. All BAS-related submittals, including those related to software and sequences as well as hardware, shall conform to the requirements described in Section 25 50 00.

4. Non-conforming submittals shall be returned without action.

B. Submittals shall be provided in searchable digital format, as required by Section 25 50 00.

1. Provide a separate file for each submittal.

2. Product cutsheets, test forms and other text documents shall be provided in a word searchable digital format. Acceptable formats are MS Word, PDF and HTML; other formats require approval prior to submission.

3. Drawings and schematics shall be provided in PDF format.

4. Sequences of operations shall be submitted in MS Word format.
5. PDFs shall be generated from another electronic document shall be word-searchable; scans/images of paper documents will not be accepted.
6. Image scans may be submitted only for original signed documents, such as qualifications, inspection certificates, and warranty documents.
7. Hardcopy (paper) submittals are not acceptable and shall not be provided except as specified during Closeout/Completion (see Section 25 50 00).
8. Submittals provided in the wrong format will be returned without action.

C. Parameters Determined in Balancing
1. Article 3.2 lists parameters and setpoints that must be determined during Test and Balance, to support BAS programming.
2. As described in Section 25 50 00, DDC Contractor shall coordinate with Test and Balance Contractor to develop a coordination plan for determining these parameters. DDC Contractor shall also submit these parameters for review after they have been determined, in the Setpoint Determination Report. See Articles “Submittals” in Part 1 and “Coordination with Other Trades” in Part 3 of Section 25 50 00.
3. When submitting these parameters for review, DDC Contractor shall flag any values that seem anomalous, outside of expected range, or otherwise problematic.
4. DDC Contractor shall not commence with functional testing or verification until these parameters have been established and programmed, and documentation has been submitted to and accepted by the Engineer of Record. Any testing performed prematurely shall be repeated in full after these parameters have been determined and accepted.

D. DDC Contractor Review of Sequences of Operations
1. DDC Contractor shall review these Sequences of Operations and document to Engineer of Record any concerns with regards to the ability to implement the sequences as written. The DDC Contractor shall identify and address any of the following conditions:
   a. Apparent errors in control sequence logic.
   b. Discrepancies or inconsistencies within the control sequences.
   c. Missing information required for programming.
   d. Control logic which might damage equipment or violate manufacturer warranties.
   e. Control logic elements which cannot be implemented due to inherent limitations of the control hardware or software system to be used.
   f. Suggest alternative; control strategies, or implementations which provide improved functionality or equivalent functionality with less effort.
2. DDC Contractor is strongly encouraged to provide this feedback via an informal pre-submittal (see Section 25 50 00) to resolve any issues or concerns in advance of formal submission.
3. DDC Contractor shall submit both English-language Sequence of Operations and the actual control logic (in line code or visual logic) as part of the regular submittal process. See “Submittals” in Part 1 of Section 25 50 00.
   a. The intent and implementation of submitted Sequences of Operations and submitted programming logic shall match and be fully consistent with each other.
   b. DDC Contractor shall document any as-programmed changes or discrepancies relative to the Sequences of Operations provided in this Section. Changes shall be clearly marked.
   c. The Engineer of Record may reject any control logic changes which have not been pre-approved. DDC Contractor shall be responsible for all re-programming, re-testing and other work required to correct or refine control logic changes which were not pre-approved by the Engineer of Record.
4. All changes to Sequences of Operations require review and approval of the Engineer of Record.
5. Changes which are inconsistent with the intent of the Sequences of Operations or that may negatively impact energy consumption or occupant comfort are not acceptable will be rejected.

6. Only the Sequences of Operations reviewed and accepted by the Engineer of Record shall be installed and or programmed into the DDC System.

1.5 COORDINATION

A. DDC Contractor is responsible for coordinating with other trades, equipment manufacturers, and commissioning agents to facilitate the Work of this and related Sections. The full scope of DDC Contractor coordination responsibility is outlined in Part 1 and Part 3 of Section 25 50 00.

B. Relative to the Work of this Section, DDC Contractor shall coordinate with the TAB (Test and Balance) Contractor to establish the correct values for the field-determined critical control parameters required to program the Sequences of Operations.

1. DDC Contractor shall provide a list of setpoints and other parameters to be determined by the TAB Contractor.
   a. See Article 3.2 for required setpoints identified by Engineer of Record. This list may not be complete. DDC Contractor is responsible for identifying all setpoints which require TAB coordination and are necessary for correct execution of Sequences of Operations.

2. The DDC Contractor shall review and comment on TAB test procedures and forms that relate to the setpoints in Article 3.2 before the contractor begins work (and others as identified by the DDC Contractor or Engineer of Record) to ensure that they will provide information required to correctly program Sequences of Operations.

3. Submit Setpoint Determination Plan with DDC Submittal Package 3 (see “Submittals” in Part 1 of Section 25 50 00).
   a. Plan shall include a brief narrative description of the means and methods to be used to determine specified setpoints and other system parameters.
   b. Plan shall also include copies of the data record sheets to be used during testing.

4. DDC Contractor shall support work by the TAB Contractor as necessary, to facilitate the determination of critical control setpoints.

5. After setpoint determination is complete, DDC Contractor shall submit Setpoint Determination Report, documenting results of all tests and the final setpoints that were determined (refer to 1. above). The DDC Contractor shall use these values for initial BAS programming.
   a. In the Setpoint Determination Report, the DDC Contractor shall flag any values that seem anomalous, outside of the expected range, or otherwise problematic.

1.6 TRENDS

A. General

1. Trends shall be configured, recorded, and stored as described in Section 25 50 00.

2. Standard BACnet trend objects shall be used exclusively.
3. All time-basis trends shall be synchronized to record data at the same time for ease of side-by-side comparison. Trends with the same time basis but offset timestamps (e.g. one-point trends at 1:00, 1:05, 1:10, etc while another point trends at 1:02, 1:07, 1:12, etc.) shall not be accepted.

4. DDC Contractor shall not create duplicate trends of a single point. If a single point referenced for trending in this, or other Sections appears more than once, that does not indicate that multiple trends shall be created. Create only one trend for any given physical or virtual point, unless specifically instructed otherwise.

B. Trend Intervals and Basis (unless otherwise indicated)

1. Binary points shall be trended on a change-of-value (COV) basis.

2. Analog points shall be trended on a time basis with a frequency of 5 minutes or as scheduled/indicated on Contract Drawing control schematics and/or this Section.
   a. If an analog point is indicated for COV trending with a value in engineering units (e.g. “2°F COV”), provide trend which records a timestamp and point value every time the point value changes at least the given increment.
   b. If an analog point is indicated for COV trending with a percentage value (e.g. “±10% COV”), provide trend which records a timestamp and point value every time the point value changes by at least that percentage of its current value.

3. Fixed and manually-adjustable setpoints shall be trended on a COV basis, with a minimum of one data point recorded per day, at noon. (The minimum single data point provides a reference for subsequent trend analysis.)

4. Zone and System Modes shall be trended on a COV basis, with one minimum of one data point recorded per day, at noon.

5. Setpoints which are reset by control logic shall be trended on a time basis with a frequency of 5 minutes or as indicated by the Control drawings.
   a. Exception: Setpoints that are reset by a Request-based Trim & Respond logic (see Paragraph 3.3A.14) shall be trended with the same frequency as the Trim & Respond time step T. The number of requests (see below) shall be trended on the same frequency.
   b. If a setpoint is reset by another data point, that point shall be trended at the same time (e.g. if SAT is reset on OAT, both OAT and SAT shall be trended simultaneously).

C. Data and Points to Be Trended

1. All hardwired and networked points listed in points schedules on Contract Drawing control schematics.

2. All zone temperatures, including radiant mass temperatures (measured by embedded slab sensor) if applicable.

3. All alarms, including alarms generated by dedicated equipment controllers and alarms calculated by these Sequences.

4. The Operating Mode of each zone (see Paragraph 3.3C.6)

5. The System Mode of each air handling unit (see Paragraph 3.3H.8.a)

6. The status of each zone with an occupancy sensor, whether that sensor is directly connected to the BAS or is mapped from an interconnected lighting control system.

7. All setpoints used for control, and their associated actual values (e.g. trend both CHW supply temp setpoint and actual CHW supply temp). This includes setpoints which are “fixed” (i.e. only adjustable through operator’s interface), adjustable by occupants, or reset by control logic, including but not limited to:
   a. All zone heating and cooling setpoints (including local setpoint adjustments)
   b. Terminal unit discharge air temperature setpoints
   c. Air handler supply air temperature setpoints
d. Hydronic plant (i.e. chiller, boiler, heatpump etc) CHW and/or HHW supply and/or return temperature setpoints.

e. Domestic hot water plant DHW supply and/or return temperature setpoints

f. Building and space pressure setpoints

g. Duct static pressure setpoints

h. Hydronic loop differential pressure setpoints

8. Signal value output of all control loops, except those that drive a single AO point that is already being trended.

9. The number of requests for each Trim & Respond loop. Each type of request for each Trim & Respond loop shall be trended separately, including but not limited to:

   a. All zone heating, cooling and pressure reset requests (in terminal unit sequences, under System Requests), separately for each zone and request type

   b. All air handler CHW Supply Temperature Reset Requests and HHW Supply Temperature Reset Requests (in AHU sequences under Plant Requests), separately for each zone and request type

10. All plant requests such as cooling plant requests and heating plant requests.

11. All global override events (e.g. demand response, or after-hours override operation).

12. All resource and utility meters connected to the DDC system.

13. All calculated performance parameters (e.g. kW/ton) described in these Sequences.

14. All equipment loads calculated and/or used for control (e.g. chiller %FLA) in these Sequences.

15. All of the listed network points for the following equipment. These points are in addition to those shown on the Contract Drawing control schematics. However, DDC Contractor shall not create duplicate trends: if the same point appears on both the drawings and in the lists below, create only one trend.

   a. Variable Frequency Drive (VFD)

<table>
<thead>
<tr>
<th>Point Description</th>
<th>Type</th>
<th>Trend Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>On/off status</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Fault (Critical Alarm)</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Minor Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Fault Text</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Alarm Text</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Fault Reset</td>
<td>BO</td>
<td>COV</td>
</tr>
<tr>
<td>Keypad in Hand/Auto</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Minimum Frequency Setpoint</td>
<td>AO</td>
<td>±5% COV</td>
</tr>
<tr>
<td>Maximum Frequency Setpoint</td>
<td>AO</td>
<td>±5% COV</td>
</tr>
<tr>
<td>Acceleration Rate</td>
<td>AO</td>
<td>±5% COV</td>
</tr>
<tr>
<td>Deceleration Rate</td>
<td>AO</td>
<td>±5% COV</td>
</tr>
<tr>
<td>Actual Frequency (Speed Feedback)</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>AC Output Voltage</td>
<td>AI</td>
<td>±10% COV</td>
</tr>
<tr>
<td>Current</td>
<td>AI</td>
<td>15 minutes</td>
</tr>
<tr>
<td>VFD Temperature</td>
<td>AI</td>
<td>60 minutes</td>
</tr>
<tr>
<td>Power, kW</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Energy, MWh</td>
<td>AI</td>
<td>15 minutes</td>
</tr>
<tr>
<td>DC Bus Voltage</td>
<td>AI</td>
<td>±10% COV</td>
</tr>
</tbody>
</table>
b. 2-Pipe (HHW or CHW, selectable) Heat Pump

<table>
<thead>
<tr>
<th>Point Description</th>
<th>Type</th>
<th>Trend Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Loop CHW/HHW Supply Temperature</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Primary Loop CHW/HHW Return Temperature</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>CHW/HHW Mode Select</td>
<td>BO</td>
<td>COV</td>
</tr>
<tr>
<td>CHW/HHW Supply Temp Setpoint Command</td>
<td>AO</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Active Supply Temp Setpoint</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Compressor Status, typ for each compressor</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Compressor Load (% FLA), typ for each compressor</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Primary (on skid) Pump 1 Status</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Primary (on skid) Pump 2 Status</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Fan 1 Speed</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Fan 2 Speed</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Defrost Status</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Evaporator Flow Meter Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Recovery Flow Meter Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Evap Pump 1 Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Evap Pump 2 Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Recovery Pump 1 Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Recovery Pump 2 Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Compressor Alarm, typ per compressor</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Fan 1 Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Fan 2 Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Low Pressure Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>High Pressure Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Faulty Probe Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Maintenance Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Antifreeze Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>High System Temp</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>High Recovery Temp</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Sum of All Alarms</td>
<td>AI</td>
<td>COV</td>
</tr>
</tbody>
</table>

c. 4-Pipe (simultaneous HHW and CHW) Heat Pump

<table>
<thead>
<tr>
<th>Point Description</th>
<th>Type</th>
<th>Trend Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Loop HHW Supply Temperature</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Primary Loop HHW Return Temperature</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Point Description</td>
<td>Type</td>
<td>Trend Basis</td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>HHW Supply Temp Setpoint Command</td>
<td>AO</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Active HHWST Setpoint</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Primary Loop CHW Supply Temperature</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Primary Loop CHW Return Temperature</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>CHW Supply Temp Setpoint Command</td>
<td>AO</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Active CHWST Setpoint</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Compressor Status, typ for each compressor</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Compressor Load (% FLA), typ for each compressor</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>CHW Primary (on skid) Pump 1 Status</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>CHW Primary (on skid) Pump 2 Status</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>HW Primary (on skid) Pump 1 Status</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>HW Primary (on skid) Pump 2 Status</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Fan 1 Speed</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Fan 2 Speed</td>
<td>AI</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Defrost Status</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Evaporator Flow Meter Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Recovery Flow Meter Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Evap Pump 1 Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Evap Pump 2 Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Recovery Pump 1 Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Recovery Pump 2 Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Compressor Alarm, typ per compressor</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Fan 1 Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Fan 2 Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Low Pressure Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>High Pressure Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Faulty Probe Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Maintenance Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Antifreeze Alarm</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>High System Temp</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>High Recovery Temp</td>
<td>BI</td>
<td>COV</td>
</tr>
<tr>
<td>Sum of All Alarms</td>
<td>AI</td>
<td>COV</td>
</tr>
</tbody>
</table>
d. Equipment not listed here, but noted to have BACNET connection: submit list of networked points for approval.

PART 2 - PRODUCTS (not applicable)

PART 3 - EXECUTION

3.1 CONTROL PARAMETERS PROVIDED BY ENGINEER OF RECORD

A. General
1. None for this equipment.

B. Generic Thermal Control Zones
1. Outdoor Air Ventilation Requirements
   a. The parameters required to calculate minimum outdoor airflow for each zone shall be scheduled on the drawings
   b. California Title 24 ventilation requires the following parameters:
      1) \( V_{occ-min} \): Zone minimum outdoor airflow for occupants, per Title 24 prescribed CFM-per-occupant requirements.
      2) \( V_{area-min} \): Zone minimum outdoor airflow for building area, per Title 24 prescribed CFM-per-ft\(^2\) requirements.

2. CO2 Setpoints
   a. All occupancy types: 800 ppm

3. Thermal Control Zone Temperature Setpoints
   a. Zone Temperature default setpoints shall be based on zone type as scheduled on the drawing: M0.04.
   b. When zones are unoccupied, they shall be controlled to their “standby” setpoints.

C. Thermal Control Zone Group Assignments and Scheduling
1. Zones shall be assigned to Groups as shown in the following table.
2. Zone Groups and default schedules shall be confirmed with Owner prior to programming.

<table>
<thead>
<tr>
<th>Zone Group Name</th>
<th>AH Tag</th>
<th>Default Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 Non-Lab Classroom &amp; Support Spaces</td>
<td>AHU-1</td>
<td>WD: 6am to 8pm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WE, HOL: Off</td>
</tr>
<tr>
<td>Level 1 Labs and Lab offices</td>
<td>AHU-1</td>
<td>WD: 6am to 8pm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WE, HOL, Nights: Min ACH</td>
</tr>
<tr>
<td>Level 2 Non-Lab Classroom, Offices &amp; Support Spaces</td>
<td>AHU-1</td>
<td>WD: 6am to 8pm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WE, HOL: off</td>
</tr>
<tr>
<td>Level 2 Labs and Lab offices</td>
<td>AHU-1</td>
<td>WD: 6am to 8pm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WE, HOL, Nights: Min ACH</td>
</tr>
<tr>
<td>IDF/MEP/Electrical rooms</td>
<td>AHU-1</td>
<td>ALL: 12am to 12am (occupied 24/7)</td>
</tr>
</tbody>
</table>
D. CH/HHW Plant (Air Source Heat Pump: ASHP-1,2,3 & Pumps)
   1. Supply Temperature Setpoint
      a. HWS setpoint shall be 100 deg F.
      b. CHWS setpoint shall be 55 deg F.

E. Lab Supply Air Valve, 4-pipe Heating & Cooling Switchover
   1. The design airflow setpoints for each zone shall be scheduled on the drawings
      a. Vcool-max: The zone maximum cooling airflow setpoint
      b. Vmin: The zone minimum airflow setpoint
      c. Vheat-max: The zone maximum heating airflow setpoint

F. Lab Exhaust Air Valve, General
   1. The design airflow setpoints for each zone shall be scheduled on the drawings
      a. Vmax: The occupied general exhaust
      b. Vmin: The unoccupied general exhaust

G. Lab Exhaust Air Valve, Fume Hood
   1. The design airflow setpoints for each zone shall be scheduled on the drawings
      a. Vmax: The exhaust airflow setpoint with hood full open
      b. Vmin: The exhaust airflow setpoint with hood full closed

H. VAV Supply Terminal Unit, 4-pipe Heating & Cooling Switchover
   1. The design airflow setpoints for each zone shall be scheduled on the drawings
      a. Vcool-max: The zone maximum cooling airflow setpoint
      b. Vmin: The zone minimum airflow setpoint
      c. Vheat-max: The zone maximum heating airflow setpoint
   2. MinDAT: The minimum cooling discharge air temperature shall be 55°F unless otherwise scheduled on the drawings.
   3. MaxΔT: The maximum heating discharge air temperature above zone heating setpoint shall be 30°F unless otherwise scheduled on the drawings.

I. Typical Cooling-only FCU Zone
   1. SA Temperature Setpoint: 55°F

J. Air Handling Unit System Modes
   1. No parameters required.

K. Multiple Zone VAV Air Handling Unit
   a. Min_ClgSAT= 55°F: The lowest supply air temperature setpoint
   b. Max_ClgSAT= 70°F: The highest supply air temperature setpoint (chosen to maximize heat recovery)
   c. OAT_Min = 55°F: The bottom of the OAT reset range
   d. OAT_Max = 70°F: The top of the OAT reset range
   2. The ventilation setpoints shall be scheduled on the drawings
      a. California Title 24 ventilation requires the following parameters:
1) **AbsMinOA**: The design minimum outdoor air rate when all zones with CO₂ sensors or occupancy sensors are unpopulated

2) **DesMinOA**: The design minimum outdoor airflow with areas served by the system occupied at their design population, including diversity where applicable

3. **Economizer High Limit Lockout**: Economizer shall be disabled whenever the outdoor air conditions exceed the economizer high limit as specified below.
   a. All units: $T_{OA} >$

L. **Lab Exhaust Fans**
   1. Minimum Airflow velocity: 2,000 FPM
   2. Minimum Airflow velocity if someone is on Observation Deck: 4,000 FPM

M. **BAS Fire Alarm Mode**
   1. None for this section

N. **Lab Exhaust Heat Recovery**
   1. None for this section

O. **Exhaust Fan, Temperature Controlled**
   1. None for this equipment.

P. **Domestic Hot Water Plant**
   1. None for this section

Q. **Resource Meters**
   1. None for this equipment.

3.2 **FIELD-DETERMINED CRITICAL CONTROL PARAMETERS**

A. **General**
   1. As required in Article 1.5 of this Section and Part 3 of Section 25 50 00, DDC Contractor shall coordinate with and support TAB Contractor to determine the parameters listed in this Article for all equipment included in the Scope of Work under this Section.
   2. DDC Contractor shall obtain these values from TAB Contractor and program the BAS accordingly. If DDC Contractor is unable to obtain these values for any reason, or if the values obtained are not appropriate or do not make sense, DDC Contractor shall notify General Contractor and Engineer of Record in writing to request guidance.

B. **CH/HHW Plant (Air Source Heat Pump: ASHP-1,2,3 & Pumps)**
   1. Secondary Hydronic Loop Differential Pressure Setpoint

C. **Terminal Units**
   1. For all pressure-independent (i.e. possessing an airflow measurement device, a modulating damper, and closed-loop control to maintain airflow at setpoint) terminal units:
      a. DDC Contractor shall program independent K-factor (airflow sensor pickup gain) values for each terminal unit based on data obtained from Test and Balance (TAB) Contractor.
b. The use of manufacturer tables for K-factor value is not acceptable.

D. Stand-Alone Exhaust Fans

1. For each independent exhaust fan (controlled by schedule, temperature or occupancy sensor) that are not part of an air handler or building relief system determine the following parameters:
   a. Fan speed setpoint MaxSpeed: The speed which provides the exhaust airflow rate scheduled on the plans.
   b. Minimum fan speed (VFD motor frequency), determined according to “VFD Minimum Speed” in Part 3 of Section 25 50 00.
   c. Max_DSP: The exhaust duct static pressure setpoint at design (maximum scheduled airflow) conditions

E. Air Handling Units

1. Multiple Zone VAV Air Handling Unit
   a. Max_DSP: The supply duct static pressure setpoint at design (maximum scheduled airflow) conditions
   b. Minimum Fan Speeds (VFD motor frequency), determined according to “VFD Minimum Speed” in Part 3 of Section 25 50 00 for
      1) Supply Fan
      2) Return Fan
   c. Return fan airflow differential S-R-CFM-DIFF (for Return Fan Control with Airflow Tracking, see Paragraph 3.3K.6) is the differential in CFM between supply airflow and return airflow required to maintain building pressure at +0.05”.
      1) Measure differential at minimum supply airflow and design supply airflow. S-R-CFM-DIFF shall be the average of the two measurements.
      2) All return fans that normally operate with the air handler should be on.
      3) A handheld sensor reading may be used only if a permanent building pressure sensor is not provided.

F. BAS Fire Alarm Mode

1. Duct Static Pressure setpoint
   a. DSP_FA: The exhaust duct static pressure setpoint at a minimum flow condition whereby exhaust is maintained at the furthest fume hood air valve or the exhaust fan is at it’s minimum speed, whichever is higher. Refer to next section for procedure to determine.

2. Bypass Damper:
   a. BD_P1: The bypass damper position which avoids underpressurizing the labs & preventing the doors from opening when the system initially enters fire alarm mode. The procedure to determine shall be as follows:
      1) Turn off all supply and exhaust fans serving the building.
      2) Fully close the dampers of all lab supply air valves and VAV boxes.
      3) Fully close all exhaust VAV terminals except the ones serving lab fume hoods.
      4) Fully open the BD on the roof.
      5) For each LEV serving lab fume hood, command the damper position to where it can provide design air flow rate. (This is assuming all lab fume hoods are in use when fire occurs, which is the worst case.)
      6) Turn on the exhaust fans to design flow rate.
7) Measure and record the air flow rate at the furthest lab fume hood. If the furthest lab fume hood has no measurable air flow, gradually close the BD on the roof until the furthest lab fume hood get measurable air flow.

8) Measure and record the opening force for each lab door. The door opening force shall not exceed the 2016 CBC requirement.

9) If any of the lab door opening force exceeds the 2016 CBC requirement, gradually open the BD until lab door opening force meets the 2016 CBC requirement.

10) Measure and record the bypass damper position BD_P1

b. BD_P2: The bypass damper position which enables the fan to run at minimum speed and achieve flow at the furthest fume hood. The procedure to determine shall be as follows:

1) Turn off two exhaust fans, run only on exhaust fan at the minimum speed.
2) Fully close the BD on the roof.
3) Measure and record the air flow rate at each lab fume hood. If any of the lab fume hood has no measurable air flow, increase the exhaust fan speed until all lab fume hoods get measurable air flow.
4) Measure and record the opening force for each lab door. The door opening force shall not exceed the 2016 CBC requirement.
5) If any of the lab door opening force exceeds the 2016 CBC requirement, gradually open the BD until lab door opening force meets the 2016 CBC requirement.
6) Repeat Step. 7 until all lab doors met the 2016 CBC requirement.
7) Measure and record the air flow rate at each lab fume hood.
8) Measure and record opening force of each lab door again.
9) Measure and record the bypass damper position BD_P2.
10) Measure and record the setpoint of DSP_FA. This number will be used for exhaust fan control in fire alarm mode.

c. T: The time it takes the fan(s) to slow from design maximum speed to one fan running at minimum fire alarm speed.

3.3 SEQUENCES OF OPERATIONS

A. General

1. Unless otherwise indicated, control loops shall be enabled and disabled based on the status of the system being controlled to prevent wind-up.
2. When a control loop is enabled or re-enabled, it and all its constituents (such as the proportional and integral terms) shall be set initially to a Neutral value.
3. A control loop in Neutral shall correspond to a condition that applies the minimum control effect, i.e. valves/dampers in normal position, VFDs at minimum speed, etc.
4. When there are multiple outdoor air temperature sensors, the system shall use the valid sensor that most accurately represents the outdoor air conditions at the equipment being controlled.

a. Outdoor air temperature sensors at air handler outdoor air intakes shall be considered valid only when the supply fan is proven on and unit is in Occupied Mode or any other Mode in which the economizer is enabled.
b. The outdoor air temperature used for graphics display, optimum start, plant lockout, and other global sequences shall be the average of all valid sensor readings. If there are four or more valid outdoor air temperature sensors, discard the highest and lowest temperature readings.

5. The term "proven" (i.e. "proven on"/ "proven off") shall mean that the equipment’s BI status point matches the state set by the equipment’s BO command point.

6. The term “software point” shall mean an analog variable, and “software switch” shall mean a digital (binary) variable, that are not associated with real I/O points. They shall be read/write capable (e.g. BACnet analog variable and binary variable).

7. The term “control loop” or “loop” is used generically for all control loops. These will typically be PID loops, but proportional plus integral plus derivative gains are not required on all loops. Unless specifically indicated otherwise, the following guidelines shall be followed:
   a. Use proportional only (P-only) loops for limiting loops (such as zone CO2 control loops, etc.).
   b. Do not use the derivative term on any loops unless field tuning is not possible without it.

8. To avoid abrupt changes in equipment operation, the output of every control loop shall be limited by a user adjustable maximum rate of change, with a default of 25% per minute.

9. All setpoints, timers, deadbands, PID gains, etc. listed in sequences shall be adjustable by the user with appropriate access level whether indicated as adjustable in sequences or not. Software points shall be used for these variables. Fixed scalar numbers shall not be embedded in programs except for physical constants and conversion factors.

10. Values for all points, including real (hardware) points used in control sequences shall be capable of being overridden by the user with appropriate access level (e.g. for testing and commissioning). If hardware design prevents this for hardware points, they shall be equated to a software point and the software point shall be used in all sequences.

11. Alarms
   a. There shall be 5 levels of alarm
      1) Level 1: Life Safety Message
      2) Level 2: Critical Equipment Message
      3) Level 3: Urgent Message
      4) Level 4: Normal Message
      5) Level 5: Maintenance Notification
   b. All alarms generated by the BAS shall include at least the following information:
      1) Date and time of the alarm
      2) Level of the alarm
      3) Description of the alarm
      4) Equipment tags for the units in alarm
      5) Possible causes of the alarm, if provided by the fault detection routines
      6) The Source per Paragraph 3.3A.12.a.1) which serves the equipment in alarm
   c. Maintenance Mode
      1) Operators shall have the ability to put any piece of equipment in/out of maintenance mode via switch on graphics.
      2) All alarms associated with a device in maintenance mode will be suppressed, except for life safety alarms which shall not be suppressed.
      3) Every device that is in maintenance mode shall issue Level 3 alarm daily, indicating the device is still in maintenance mode. The timing of this alarm shall be adjustable by operators; initially it shall occur at 9AM.
d. Entry Delays
   1) All alarms shall have an adjustable delay time such that the alarm is not triggered unless the alarm conditions are met continuously for the duration of the delay period.
   2) Default entry delays apply to all alarms unless otherwise indicated:
      a) Level 1 alarms: 1 second
      b) Level 2 alarms: 10 seconds
      c) Level 3 alarms: 1 minute
      d) Level 4 alarms: 5 minutes
      e) Level 5 alarms: 15 minutes

e. Exit Hysteresis
   1) Each alarm shall have an adjustable time-based hysteresis (default: 5 seconds) to exit the alarm. Once set, the alarm does not return to normal until the alarm conditions have ceased for the duration of the hysteresis.
   2) Each alarm shall have an adjustable time-based hysteresis to exit the alarm. Once set, the alarm does not restore to normal until the alarm conditions have ceased for the specified duration.
      a) The time-to-exit hysteresis for all alarms shall be 5 seconds unless otherwise indicated.
   3) Each analog alarm shall have an adjustable % of limit-based hysteresis (default: 0% of the alarm threshold, i.e. no hysteresis; alarm exits at the same value as the alarm threshold) the alarmed variable required to exit the alarm. Alarm conditions have ceased when the alarmed variable is below the triggering threshold by the amount of the hysteresis.
   4) Each analog alarm shall have a % of limit-based hysteresis for the value of the alarmed variable required to exit the alarm. Once set, the alarm does not restore to normal until the alarmed variable is below (or above, as appropriate to the alarm) the triggering threshold by the specified amount.
      a) The % of limit-based hysteresis for all (analog) alarms shall be 0% of the alarm threshold (i.e. no deadband; alarm exits at the same value that triggers alarm) unless otherwise indicated.

5) Exit hysteresis is independent of latching periods (below).

f. Latching
   1) Any alarm can be configured as latching or non-latching.
      a) A latching alarm requires acknowledgement from the operators before it can return to normal even if the exit deadband has been met.
      b) A non-latching alarm does not require acknowledgement
   2) Default latching status shall apply to all alarms unless otherwise indicated:
      a) Level 1 alarms: Latching
      b) Level 2 alarms: Latching
      c) Level 3 alarms: Non-latching
      d) Level 4 alarms: Non-latching
      e) Level 5 alarms: Non-latching

g. Post-Exit Suppression Period
   1) To minimize nuisance alarms, each alarm shall have an adjustable suppression period.
2) Any given alarm may not re-occur until the alarm has been cleared for the suppression period. (Suppression periods apply separately to each alarm for each piece of equipment. Other alarms from the same equipment, or the same alarm from other equipment, is not affected by the suppression period.)

3) Default suppression periods shall apply to all alarms unless otherwise indicated:
   a) Level 1 alarms: 0 minutes
   b) Level 2 alarms: 5 minutes
   c) Level 3 alarms: 24 hours
   d) Level 4 alarms: 7 days
   e) Level 5 alarms: 7 days

h. Time-Based Suppression (for zones)
   1) After a change in setpoint, zone reset requests (see Paragraph 3.3A.14.c) and zone temperature alarms are suppressed for a period of time, as given below.
      a) This includes automatic changes in setpoint (e.g. due to occupancy sensor, or change in zone Mode) as well as changes made by the occupants.
   2) After any change in setpoint, calculate a time delay period based on the difference between the controlled variable (e.g. zone temperature) at the time of the change and the new setpoint. The default time delay period shall be:
      a) For thermal zone temperature alarms: 10 minutes per °F of difference up to a maximum of 120 minutes.
      b) For thermal zone temperature cooling requests: 5 minutes per °F of difference up to a maximum of 30 minutes.
      c) For thermal zone temperature heating requests: 5 minutes per °F of difference up to a maximum of 30 minutes.
   3) Time-based suppression periods are independent of post-exit suppression periods. They are not cumulative.

i. Operator Acknowledgement of Alarms
   1) For both latching and non-latching alarms, the operators may acknowledge the alarm.
   2) Acknowledging an alarm clears the alarm, the exit deadband, and the suppression period. An acknowledged alarm can re-occur as soon as the entry delay elapses.

12. Hierarchical Alarm Suppression
   a. For each piece of equipment or space controlled by the BAS, define within BAS programming the device’s relationship (if any) to other equipment in terms of “source”, “load”, or “system”.
      1) A component is a “source” if it provides resources to a downstream component, such as a chiller providing chilled water to an AHU.
      2) A component is a “load” if it receives resources from an upstream component, such as an AHU that receives chilled water from a chiller.
      3) The same component may be both a load (receiving resources from an upstream source) and a source (providing resources to a downstream load).
      4) A set of components is a “system” if they share a load in common (i.e. collectively act as a source to downstream equipment, such as a set of chillers in a lead/lag relationship serving air handlers).
a) If a single component acts as a source for downstream loads (e.g. an AHU as a source for its VAV boxes), then that single source component shall be defined as a "system" of one element.

b) For equipment with associated pumps (chillers, boilers, cooling towers):

   (1) If the pumps are in a one-to-one relationship with equipment they serve, the pumps shall be treated as part of the system to which they are associated (i.e. they are not considered loads) since a pump failure will necessarily disable its associated equipment.

   (2) If the pumps are headered to the equipment they serve, then the pumps may be treated as a system, which is a load relative to the upstream equipment (e.g. chillers) and a source relative to downstream equipment (e.g. air handlers).

c. SystemOK shall be true when all of the following are true:

1) The system is proven on.
2) The system is achieving its temperature and/or pressure setpoint(s) for at least 5 minutes
3) The system is ready and able to serve its load

d. SystemOK shall be false while the system is starting up (i.e. before reaching setpoint) or when enough of the system’s components are unavailable (in alarm, disabled, or turned off) to disrupt the ability of the system to serve its load. This threshold shall be defined by the design engineer for each system.

   1) By default, Level 1 through Level 3 component alarms (indicating equipment failure) shall inhibit SystemOK. Level 4 and Level 5 component alarms (maintenance and energy efficiency alarms) shall not affect SystemOK.

   2) The operator shall have the ability to individually determine which component alarms may or may not inhibit SystemOK.

e. The BAS shall selectively suppress (i.e. fail to announce; alarms may still be logged to a database) alarms for load components if SystemOK is false for the source system which serves that load.

   1) If SystemOK is false for a cooling water system (i.e. chiller, cooling tower, or associated pump) then only high temperature alarms from the loads shall be suppressed.

   2) If SystemOK is false for a heating water system (i.e. boiler or associated pump) then only low temperature alarms from the loads shall be suppressed.

   3) If SystemOK is false for an airside system (air handler, fan coil, VAV box, etc.) then all alarms from the loads shall be suppressed.

f. This hierarchical suppression shall cascade through multiple levels of load-source relationship, such that alarms at downstream loads shall also be suppressed.

g. The following types of alarms will never be suppressed by this logic:

   1) Life/safety and Level 1 alarms

   2) Failure-to-start alarms (i.e. equipment is commanded on, but status point shows equipment to be off)

   3) Failure-to-stop/hand alarms (i.e. equipment is commanded off, but status point shows equipment to be on)
13. VFD Speed Points
   a. The speed analog output sent to VFDs shall be configured such that 0% speed corresponds to 0 Hz and 100% speed corresponds to maximum speed configured in the VFD.
   b. Speed signal shall scale linearly from 0% to 100%. For example, if the maximum speed is 80Hz (as is the case with some fan arrays), then a 50% speed command signal would correspond to device speed of 40Hz.
   c. For each VFD, the minimum speed shall be stored in a single BAS software point.
      1) This value shall be written to the VFD’s minimum speed setpoint via the drive’s network interface every 15 minutes.
      2) If the VFD speed command is hardwired, software shall ensure that the minimum speed is the lowest speed command ever sent to the drive by the BAS.
   d. Determine minimum speed as described under “Testing and Commissioning” in Part 3 of Section 25 50 00.

14. Request-Based Trim & Respond (T&R) Setpoint Reset Logic
   a. Trim & Respond logic is a type of demand-based setpoint reset for air handlers and plants. It periodically resets the setpoint at an “upstream” system (e.g. air handler) based on Requests from “downstream” devices (e.g. terminal units), adjusting the setpoint at define time-step frequency.
   b. Trim & Respond setpoint reset logic and zone/system reset Requests where referenced in sequences shall be implemented as described below.
   c. A “Request” is a call to reset a static pressure, or temperature setpoint, generated by downstream zones or air handling systems. These Requests are sent upstream to the plant or system that serves the zone or air handler that generated the Request.
      1) For each downstream zone or system, and for each type of setpoint reset Request listed for the zone/system, provide the following software points:
         a) Importance Multiplier (default = 1)
         b) Request-Hours Accumulator: Only when System OK (see Paragraph 3.3A.12) is true for the zone/system. Every X minutes (default 5 minutes), add X divided by 60 times the current number of Requests to the request-hours accumulator point.
         c) Run-Hours Total: For each zone or system, count the number of hours operating in any Mode other than Unoccupied Mode.
            (1) The BACnet Runtime Log object shall not be used for this purpose, as this variable must be reset periodically whereas the Runtime Log must show an accurate figure for total equipment operating hours.
            d) Cumulative%Request-Hours: This is the zone/system Request-Hours divided by the zone/system Run-Hours since the last reset, expressed as a percentage.
            e) The Request-Hours Accumulator and the Run-Hours Total are reset to zero periodically as noted here.
               (1) Reset automatically for an individual zone/system whenever the Run-Hours Total for that zone/system exceed 400 hours.
               (2) Reset manually by an operator command. This command will simultaneously reset the request-hours point for all zones served by the system, or for all systems served by the plant.
f) For each system/plant receiving requests from downstream zones/systems, provide an operator's interface screen that will display for each zone/system the quantity of Requests that are currently active and the current Cumulative Request-Hours. Provide this information for each type of Request separately.

g) A Level 4 alarm shall be generated if any of the following is true; the zone Importance Multiplier is greater than zero, the zone/system Cumulative Request-Hours exceeds 70%, or the total number of zone/system run hours exceeds 40.

2) See zone and air handling system control sequences for the logic to generate Requests.

3) Multiply the number of Requests determined from zone/system logic times the Importance Multiplier and send this result to the system/plant that serves that zone/system. See the system/plant logic to see how Requests are used in the Trim & Respond logic.

d) For each upstream system or plant setpoint being controlled by a T&R loop, define the following variables. Initial values are defined in system/plant sequences below. Values for trim, respond, time step, etc. shall be tuned to provide stable control of the applicable system/plant.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Associated Equipment or System</td>
</tr>
<tr>
<td>SP₀</td>
<td>Initial setpoint</td>
</tr>
<tr>
<td>SPₘᵋᵣᵣ</td>
<td>Minimum setpoint</td>
</tr>
<tr>
<td>SPₘₐₓ</td>
<td>Maximum setpoint</td>
</tr>
<tr>
<td>Tₜ</td>
<td>Delay timer</td>
</tr>
<tr>
<td>T</td>
<td>Time step</td>
</tr>
<tr>
<td>I</td>
<td>Number of Ignored Requests</td>
</tr>
<tr>
<td>R</td>
<td>Number of Requests from zones/systems</td>
</tr>
<tr>
<td>SPₜᵦᵣᵣ</td>
<td>Trim amount</td>
</tr>
<tr>
<td>SPₐₑᵢₛ</td>
<td>Respond amount (must be opposite in sign to SPₜᵦᵣᵣ)</td>
</tr>
<tr>
<td>SPₐₑᵢₛ-ₘₐₓ</td>
<td>Maximum response per time interval (must be same sign as SPₐₑᵢₛ)</td>
</tr>
</tbody>
</table>

e) Trim & Respond logic shall reset setpoint within the range SPₘᵋᵣᵣ to SPₘₐₓ. When the associated device (e.g. fan, pump) is off, the setpoint shall be SP₀. The reset logic shall be active while the associated device is proven on, starting Tₜ after initial device start command. When active, every time step T, trim the setpoint by SPₜᵦᵣᵣ. If there are more than I Requests, respond by changing the setpoint by SPₐₑᵢₛ* (R-I), (i.e. the number of Requests minus the number of Ignored Requests), but no more than SPₐₑᵢₛ-ₘₐₓ. In other words, every time step T:

Change setpoint by SPₜᵦᵣᵣ
If R>I, also change setpoint by (R-I)*SPₐₑᵢₛ but no larger than SPₐₑᵢₛ-ₘₐₓ
### Variable Definitions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Supply Fan</td>
</tr>
<tr>
<td>$SP_0$</td>
<td>0.5</td>
</tr>
<tr>
<td>$SP_{\text{min}}$</td>
<td>0.15</td>
</tr>
<tr>
<td>$SP_{\text{max}}$</td>
<td>1.50</td>
</tr>
<tr>
<td>$T_d$</td>
<td>5</td>
</tr>
<tr>
<td>$T$</td>
<td>2</td>
</tr>
<tr>
<td>$I$</td>
<td>2</td>
</tr>
<tr>
<td>$SP_{\text{trim}}$</td>
<td>-0.04</td>
</tr>
<tr>
<td>$SP_{\text{res}}$</td>
<td>0.06</td>
</tr>
<tr>
<td>$SP_{\text{res-max}}$</td>
<td>0.15</td>
</tr>
</tbody>
</table>

### Equipment Rotation and Staging Order

15. For each set of parallel devices, the BAS shall maintain a device order queue from first to last.

a. Upon a call to stage up, the BAS shall start the highest-ordered non-operating device in the queue. Upon a call to stage down, the BAS shall stop the lowest-ordered operating device in the queue. See device-specific sequences, below, for control logic that generates staging calls.

b. When a rotation event is triggered by logic, or an operating device goes into Alarm or into Hand (see Paragraph 3.3A.15.e), the BAS shall update the device order queue and start or stop equipment as required so that the highest-ordered equipment is operating to meet the load.

1) Unless otherwise indicated, the off device shall first be started and proven on before the device that it is replacing is shut off.

2) If rotation requires more than a single pair of devices to be stopped and started, the first pair of device start/stops shall be complete before the next pair begins.

d. Device Ordering and Rotation Events: The BAS shall be programmed to support all of the following ordering and rotation strategies. The operator shall select which strategy is in effect.

1) Automatic Even Wear Rotation

a) Upon a rotation event, the device queue is ordered from least run hours to most run hours, such that the device with the least run hours is the first device and the device with the most run hours is the last device.

b) A rotation event is triggered by any of the following:

   1. Automatically when the device with the most run hours has 30% more run hours than the device with the fewest run hours. The operator may define hours during which rotation events are not allowed to occur. If a rotation event is triggered during this lockout period, its execution will be delayed until the end of the lockout period.

   2. Automatically upon a call to stage up or down.

   3. Devices that are In Alarm or In Hand (see below) shall not subject to Even Wear Rotation.

   4. Manually triggered by the operator.
2) Periodic Rotation
   a) The order of devices changes at each rotation event so that the first device becomes the last device and each lower-order device advances by one position in the queue. Initial order shall be the order of device tags (e.g. three pumps would be ordered P-1, P-2, P-3 first to last).
   b) Devices that are in Alarm or in Hand (see below) shall not subject to Periodic Rotation.
   c) Rotation events occur on a user-defined schedule. Initial schedule shall be for rotation to occur weekly, at noon on Sunday.

3) Manual Ordering and Rotation
   a) The order of devices is set directly by the operator.
   b) The operator shall not be able to change the order of devices in Alarm or in Hand (see below).
   c) Rotation events occur when manually triggered by the operator.

4) It shall be possible to effectively mix these strategies. For example, the operator may set the device order manually, and then switch to Periodic Rotation which will subsequently rotate devices in the order established manually by the operator.

e. Alarm & Hand Operation

1) In Alarm: If the lead device has an alarm condition or has been manually switched off, a Level 2 alarm shall be generated and the device shall be set to the last position in the device order until alarm clears (if non-latching) or is acknowledged by operator (if latching). Staging of remaining devices shall follow the prevailing device ordering logic. A device in alarm can only move up in the staging order if another device goes into alarm. Alarm conditions include the following:
   a) Variable Speed Fans and Pumps
      (1) VFD critical fault is ON, or
      (2) Status point not matching its on/off command for 3 seconds after the device has been commanded on for 15 seconds, or
      (3) Supervised HOA at control panel in OFF position, or
      (4) Loss of power (e.g. VFD DC Bus voltage = zero)
   b) Constant Speed Fans and Pumps
      (1) Status point not matching its on/off command for 3 seconds after the device has been commanded on for 15 seconds, or
      (2) Supervised HOA at control panel in OFF position
   c) Chillers
      (1) Chiller alarm contact, or
      (2) Chiller is manually shut off as indicated by the status of the Local/Auto switch from chiller gateway, or
      (3) Chiller status remains off 5 minutes after command to start
   d) Boilers
      (1) Boiler alarm point is ON, or
      (2) If its leaving water temperature remains 15°F below setpoint for 30 minutes.
2) Hand Operation: If a device is on in Hand (e.g. via an HOA switch or local control of VFD), the device shall be set to the lead device and a Level 4 alarm shall be generated. The device will remain as lead until the alarm is reset by the operator. Hand operation is determined by

a) Variable Speed Fans and Pumps
   (1) Status point not matching its on/off point for 15 seconds while the device is commanded off, or
   (2) VFD in local “hand” mode, or
   (3) Supervised HOA at control panel in ON position

b) Constant Speed Fans and Pumps
   (1) Status point not matching its on/off point for 15 seconds while the device is commanded off, or
   (2) Supervised HOA at control panel in ON position

c) Chillers: Chiller is manually turned on as indicated by the status of the local/auto switch from chiller gateway.

16. Damper/Valve Position
   a. Knowledge of damper and valve position are required for proper generation of Trim & Respond reset requests.
   b. The following are acceptable methods for determining position:
      1) Analog actuator. Position may be assumed to be equal to position command signal sent to actuator.
      2) Floating actuator. Provide position feedback via analog input from actuator.

B. Generic Thermal Control Zones

1. Except as noted, this section applies to all single zone systems and sub-zones of air handling systems, such as VAV boxes, fan-powered boxes, and other terminal units.
   a. This includes low-mass radiant devices such as metal ceiling panels.
   b. This does not include high-mass radiant slab systems.

2. CO₂ Control Loop: For any zone with a CO₂ sensor
   a. See Paragraph 3.1B.2 for CO₂ setpoints.
      1) Setpoints assume an ambient concentration of 400 ppm; if the system includes an ambient CO₂ sensor, subtract 400 from these setpoints and add the ambient CO₂ sensor reading.
   b. During Occupied Mode, a P-only loop shall maintain CO₂ concentration at setpoint; reset from 0% at 200 PPM below setpoint, to 100% at setpoint.
   c. Zone CO₂ control loop signal is used to reset zone outdoor air requirements and ventilation setpoints. See Paragraphs 3.3B.3 and 3.3B.4.
   d. Loop is disabled and output set to zero when the zone is not in Occupied Mode.

3. Zone Minimum Outdoor Air Requirements
   a. For every zone that requires mechanical ventilation, the zone minimum outdoor airflow and setpoints shall be calculated depending on the governing standard or code for outdoor air requirements. Zones that do not require mechanical ventilation may disregard this section.
   b. In accordance with California Title 24, BAS shall calculate zone outdoor air setpoints as follows:
1) See Paragraph 3.1B.1 for zone outdoor air requirements Voc-min and Varea-min.

2) For each zone in Occupied Mode, calculate the zone minimum outdoor air setpoints:
   a) Zone-Abs-OA-min is equal to
      (1) 25% of Varea-min if the zone has an occupancy sensor and is unpopulated (i.e. scheduled Occupied but with no occupants currently present in the zone), else
      (2) Varea-min if the zone has a CO₂ sensor, else
      (3) Zone-Des-OA-min
   b) Zone-Des-OA-min is equal to
      (1) 25% of Varea-min if the zone has an occupancy sensor and is unpopulated (i.e. scheduled Occupied but with no occupants currently present in the zone), else
      (2) The larger of Varea-min and Voc-min otherwise.

3) For any zone in any Mode other than Occupied Mode, Zone-Abs-OA-min and Zone-Des-OA-min shall equal zero.

4) Each zone in Occupied Mode shall send the current values of Zone-Abs-OA-min and Zone-Des-OA-min to its associated air handler.

4. Zone Minimum Airflow Setpoint
   a. Zone minimum airflow setpoint logic applies only to terminal units with modulating VAV dampers served by recirculating air handlers.
      1) Vmin is the scheduled minimum for zone primary airflow. Vmin* is the active (i.e. currently-applicable) primary airflow minimum, which is reset as described below. See terminal unit sequences for application of Vmin and Vmin*.
         a) Note that Vmin* is the current minimum airflow. It is not the current airflow setpoint (called Vspt in terminal unit sequences) which may be higher.
      2) Other airflow parameters (Vcool-max, Varea-min) used below are scheduled values. See terminal unit sequences.
   b. For ventilation in accordance with California Title 24, the zone minimum airflow Vmin* shall be equal to Vmin except as follows:
      1) If the zone is in any mode other than Occupied Mode: Vmin* = 0.
      2) If the zone has an occupancy sensor and is unpopulated (i.e. scheduled Occupied but with no occupants currently present in the zone): Vmin* = 25% of Varea-min.
      3) If the zone has a CO₂ sensor, the CO₂ control loop (see Paragraph 3.3B.2) shall be used to reset Vmin*, from the zone minimum airflow setpoint Vmin at 0% loop signal to the maximum cooling airflow setpoint Vcool-max at 50% loop signal, as shown below.
4) For each zone, the CO₂ control loop signal is also sent to the air handler that serves the zone, where it is used to reset the outdoor airflow setpoint. See Paragraph 3.3K.3.a.

5. Time-Averaged Ventilation (TAV)
   a. This logic applies only to terminal units with modulating VAV dampers. It does not apply to and is not used with single-zone air handling units.
   b. For each terminal unit, determine the lowest controllable minimum airflow V_m. This value shall be stored as a software point at each terminal unit.
      1) Determine the velocity pressure sensor reading VP_m in inches H₂O that will give a reliable flow indication. If this information is not provided by the sensor manufacturer, determine the velocity pressure that will result in a digital reading from the transducer and A/D converter of 12 bits or counts (assuming a 10 bit A/D converter). This is considered sufficient resolution for stable control.
      2) Determine the minimum velocity v_m for each VAV box size and model. If the VAV box manufacturer provides an amplification factor F for the flow pickup, calculate the minimum velocity v_m as

\[
v_m = 4005 \sqrt{\frac{VP_m}{F}}
\]

Where F is not known it can be calculated from the measured CFM at 1 inch signal from the VP sensor

\[
F = \left( \frac{4005A}{CFM@1"} \right)^2
\]

where A is the nominal duct area (ft²), equal to
3) Calculate the minimum airflow setpoint allowed by the controls (Vm) for each VAV box size as

\[ Vm = \frac{\pi D^2}{24 A} \]

where \( D \) is the nominal duct diameter (inches).

c. When the active airflow setpoint (Vspt) is non-zero and is less than the lowest airflow to which the terminal unit can reliably control (Vm), the airflow setpoint shall be pulse width modulated as follows:

1) The TAV ratio shall be determined as: \( TAV_{ratio} = \frac{Vspt}{Vm} \)
2) The initial default value of the total cycle time (TCT) shall be 15 minutes
3) Open period: The VAV damper is modulated by a control loop to maintain measured airflow at \( Vm \). The duration of the open period, OP, is the larger of:
   a) 1.5 minutes or
   b) TCT multiplied by TAV_{ratio}
4) Closed period:
   a) During the closed period, the VAV damper shall be fully shut and the damper control loop shall be disabled with output set to 0. The duration of the closed period is \( CP \), where \( CP = TCT - OP \).
   b) At the end of each closed period, the VAV damper shall be commanded to the last position from the previous open period prior to re-enabling the airflow control loop.
5) During TAV mode, each cycle shall consist of an open period and a closed period which alternate until Vspt is greater than Vm.
6) When entering TAV mode, start with an initial open period of duration \( RNDM \times OP \), where RNDM is a random number between 0.0 and 1.0.

6. Zone Temperature Setpoints

a. Each zone shall have separate occupied and unoccupied heating and cooling setpoints.
b. The active setpoints shall be determined by the Operating Mode of the Zone Group (see Paragraph 3.3C.6).
   1) The setpoints shall be the occupied setpoints during Occupied Mode, Warm-up Mode, and Cool-down Mode.
   2) The setpoints shall be the unoccupied setpoints during Unoccupied Mode, Setback Mode, and Setup Mode.
c. See Paragraph 3.1B.3 for zone temperature setpoints.
d. The software shall prevent
   1) The heating setpoint from exceeding the cooling setpoint minus 2°F (i.e. the minimum difference between heating and cooling setpoints shall be 2°F)
   2) The unoccupied heating setpoint from exceeding the occupied heating setpoint; and
   3) The unoccupied cooling setpoint from being less than the occupied cooling setpoint.
e. Where the zone has a local setpoint adjustment knob/button

1) The setpoint adjustment offsets established by the occupant shall be software points that are persistent (e.g. not reset daily), but the actual offset used in control logic shall be adjusted based on limits and modes as described below.

2) The adjustment shall be capable of being limited in software.
   a) As a default, the active occupied cooling setpoint shall be limited between 72°F and 80°F.
   b) As a default, the active occupied heating setpoint shall be limited between 65°F and 72°F.

3) The active heating and cooling setpoints shall be independently adjustable, respecting the limits and anti-overlap logic described above. If zone thermostat provides only a single setpoint adjustment, then the adjustment shall move both the active heating and cooling setpoints upwards or downwards by the same amount, within the limits described above.

4) The adjustment shall only affect occupied setpoints in Occupied Mode, Warm-Up Mode, and Cool-Down Mode and shall have no impact on setpoints in all other modes.

5) Upon receiving a demand response signal, the local setpoint adjustment value shall be frozen. Further adjustment of the setpoint by local controls shall be suspended for the duration of the demand response event.

f. Demand Response Cooling Setpoint Adjustment: The active cooling setpoints for all zones shall be increased when demand response is imposed on the associated Zone Group. The operator shall have the ability to exempt individual zones from this adjustment through the normal BAS user interface. Changes due to demand response are not cumulative.

1) At Demand Response Level 1, increase setpoint by 1°F.
2) At Demand Response Level 2, increase setpoint by 2°F.
3) At Demand Response Level 3, increase setpoint by 4°F.

g. Demand Response Heating Setpoint Adjustment: The active heating setpoints for all zones shall be decreased when demand response is imposed on the associated Zone Group. The operator shall have the ability to exempt individual zones from this adjustment through the normal BAS user interface. Changes due to demand response are not cumulative.

1) At Demand Response Level 1, decrease setpoint by 1°F.
2) At Demand Response Level 2, decrease setpoint by 2°F.
3) At Demand Response Level 3, decrease setpoint by 4°F.

h. Occupancy sensors. For zones that have an occupancy sensor

1) When the sensor indicates the space has been unpopulated for 5 minutes continuously during the Occupied Mode, the active heating setpoint shall be decreased by 2°F and the cooling setpoint shall be increased by 2°F.

2) When the sensor indicates that the space has been populated for 1 minute continuously, the active heating and cooling setpoints shall be restored to their previous values.

i. Hierarchy of Setpoint Adjustments: The following adjustment restrictions shall prevail in order from highest to lowest priority:

1) Setpoint overlap restriction, see Paragraph 3.3B.6.d.1)
2) Absolute limits on local setpoint adjustment, see Paragraph 3.3B.6.e.1)
3) Demand limit
a) Occupancy sensors: Change of setpoint by occupancy sensor is added to change of setpoint by any demand limits in effect.

b) Local setpoint adjustment: Any changes to setpoint by local adjustment are frozen at the onset of the demand limiting event and remain fixed for the duration of the event. Additional local adjustments are ignored for the duration of the demand limiting event.

4) Scheduled setpoints based on Zone Group mode

7. Occupancy Override: When any occupancy override button (typically associated with a thermostat) is pressed, the call for Occupied Mode operation shall be sent up to the Zone Group control for 60 minutes.

8. Zone Temperature Control Loops

a. For each zone, two separate control loops shall operate to maintain space temperature at setpoint, the Cooling Loop and the Heating Loop.

1) The Heating Loop shall be enabled whenever the space temperature is below the current zone heating setpoint temperature, and disabled when space temperature is above the current zone heating setpoint temperature and the Loop output is zero for 30 seconds.

2) The Cooling Loop shall be enabled whenever the space temperature is above the current zone cooling setpoint temperature, and disabled when space temperature is below the current zone cooling setpoint temperature and the Loop output is zero for 30 seconds.

b. The Cooling Loop shall maintain the space temperature at the active cooling setpoint. The output of the loop shall be a virtual point ranging from 0% (no cooling) to 100% (full cooling).

c. The Heating Loop shall maintain the space temperature at the active heating setpoint. The output of the loop shall be a virtual point ranging from 0% (no heating) to 100% (full heating).

d. Loops shall use proportional + integral logic or other technology with similar performance. Proportional-only control is not acceptable, although the integral gain shall be small relative to the proportional gain. P and I gains shall be adjustable by the operator.

e. See other sections for how the outputs from these loops are used.

9. Zone State

a. Heating: when the output of the space heating control loop is nonzero and the output of the cooling loop is equal to zero.

b. Cooling: when the output of the space cooling control loop is nonzero and the output of the heating loop is equal to zero.

c. Deadband: when not in either Heating or Cooling.

10. Zone Alarms

a. Zone temperature alarms

1) High temperature alarm

a) If the zone is 3°F above cooling setpoint for 10 minutes, generate Level 3 alarm.

b) If the zone is 5°F above cooling setpoint for 10 minutes, generate Level 2 alarm.

2) Low temperature alarm

a) If the zone is 3°F below heating setpoint for 10 minutes, generate Level 3 alarm.
b) If the zone is 5°F below heating setpoint for 10 minutes, generate Level 2 alarm.

3) Suppress zone temperature alarms as follows:
   a) After zone setpoint is changed per Paragraph 3.3A.11.h.
   b) While Zone Group is in Warm-up or Cool-down Modes.
   c) For zones with an Importance Multiplier (see Paragraph 3.3A.14.c.1) of zero for its static pressure reset, SAT reset, or Hot Water reset Trim & Respond loops.

b. For zones with CO₂ sensors:
   1) CO₂ sensors: If the CO₂ concentration is less than 300 ppm, or the zone is in Unoccupied Mode for more than 2 hours and zone CO₂ concentration exceeds 600 ppm, generate a Level 3 alarm. The alarm text shall identify the sensor and indicate that it may be out of calibration.
   2) If the CO₂ concentration exceeds setpoint plus 10% for more than 10 minutes generate a Level 3 alarm.

C. Thermal Control Zone Groups

1. Each system shall be broken into separate Zone Groups composed of a collection of one or more Thermal Control Zone(s) served by a single air handler or other system. See Paragraph 3.1C for Zone Group assignments.

2. Each Zone Group shall be capable of having separate occupancy schedules and Operating Modes from other Zone Groups.

3. All zones in each Zone Group shall be in the same Zone Group Operating Mode at all times. If one zone in a Zone Group is placed in any mode other than Unoccupied Mode (due to override, sequence logic, or scheduled occupancy) all zones in that Zone Group shall enter that mode.

   a. Note that Occupied-Standby Mode (a condition that allows some zones to reduce ventilation when unpopulated during scheduled occupancy) is a subset of Occupied Mode and applies to zones individually rather than at the Zone Group level.

4. A Zone Group may be in only one mode at any given time.

5. For each Zone Group, provide a set of testing/commissioning software switches that override all zones served by the Zone Group. Provide a separate software switch for each of the zone-level override switches listed under “Testing and Commissioning Overrides” in terminal unit sequences. When the value of a Zone Group’s override switch is changed, the corresponding override switch for every zone in the Zone Group shall change to the same value. Subsequently, the zone-level override switch at may be changed to a different value. The value of the zone-level switch has no effect on the value of the Zone Group switch, and the value of the Zone Group switch only affects the zone-level switches when the Zone Group switch is changed.

6. Zone Group Operating Modes: Each Zone Group shall have the following modes:
   a. Occupied Mode: A Zone Group is in the Occupied Mode when any of the following is true:
      1) The time of day is between the Zone Group’s scheduled occupied start and stop times.
      2) Any zone occupancy override timer (initiated by local occupancy override button) is nonzero.
b. Warm-Up Mode: For each zone, the BAS shall calculate the required warm-up time based on the zone’s occupied heating setpoint, the current zone temperature, the outdoor air temperature, and a mass/capacity factor for each zone. The mass factor shall be manually adjusted or self-tuned by the BAS. If automatic, the tuning process shall be turned on or off by a software switch, to allow tuning to be stopped after the system has been trained. Warm-up Mode shall start based on the zone with the longest calculated warm-up time requirement, but no earlier than 3 hours before the start of the scheduled occupied period, and shall end at the scheduled Occupied start hour.

c. Cool-Down Mode: For each zone, the BAS shall calculate the required cool down time based on the zone’s occupied cooling setpoint, the current zone temperature, the outdoor air temperature, and a mass/capacity factor for each zone. The mass factor shall be manually adjusted or self-tuned by the BAS. If automatic, the tuning process shall be turned on or off by a software switch, to allow tuning to be stopped after the system has been trained. Cool-down Mode shall start based on the zone with the longest calculated cool-down time requirement, but no earlier than 3 hours before the start of the scheduled occupied period, and shall end at the scheduled Occupied start hour.

d. Setback Mode: During Unoccupied Mode, if any 5 zones (or all zones, if fewer than 5) or the average of all zones in the Zone Group fall below their unoccupied heating setpoints, the Zone Group shall enter Setback Mode until all spaces in the Zone Group are 2°F above their unoccupied setpoints.

e. Freeze Protection Setback Mode: During Unoccupied Mode, if any single zone falls below 40°F, the Zone Group shall enter Setback Mode until all zones are above 45°F, and a Level 3 alarm shall be set.

f. Setup Mode: During Unoccupied Mode, if any 5 zones (or all zones, if fewer than 5) or the average of all zones in the Zone Group rise above their unoccupied cooling setpoints, the Zone Group shall enter Setup Mode until all spaces in the Zone Group are 2°F below their unoccupied setpoints.

g. Unoccupied Mode: When the Zone Group is not in any other mode.

D. CH/HHW Plant (Air Source Heat Pump: ASHP-1,2,3 & Pumps)

1. After unit is installed and started up in standby mode, it is recommended to call manufacturer for assistance in setting up BMS / BACnet control.

2. The plant is designed to produce either heating hot water, chilled water, or both simultaneously.
   a. ASHP-1 is a 4-pipe heat pump that can produce both heating, cooling or both simultaneously. ASHP-1 is sized to handle the peak simultaneous load of the building.
   b. ASHP-2,3 are 2-pipe units that shall supplement the main heat pump with either heating or cooling depending on the building load.

3. Plant Enable/Disable
   a. The heat pump plant shall be enabled to run any time any zone is in Occupied Mode.
   b. The heat pumps produce hot and/or chilled water as commanded by the BMS. However, the compressors, fans and pumps shall run subject to internal controls only (no direct BMS control), in response to demand for chilled and/or hot water.
   c. When the heat pump is enabled but is not responding to a BMS request for chilled and/or hot water, it shall remain available in a minimum power standby condition.

4. Chilled Water Production
   a. ASHP-1
1) The BMS shall command heat pump ASHP-1 to produce chilled water when the secondary CHW supply temperature exceeds the CHWST setpoint + 5°F
2) When commanded to provide chilled water, ASHP-1 shall run pumps, fans, and compressors as required to provide chilled water to the primary CHW loop at the CHWST setpoint.
3) Simultaneous Heating and Cooling
   a) If any temperature sensor in the hot water buffer tank is below the HWST setpoint - 2°F, the heat pump ASHP-1 shall also produce hot water simultaneously.
   b) Simultaneous hot water production shall stop when chilled water production stops, or when the primary hot water return temperature (as measured by the heat pump internal sensor and reported by the heat pump internal controls) equals the HWST setpoint + 0°F, whichever happens first.

   (1) If chilled water production stops but there is a call to produce hot water (see logic below), the heat pump shall transition seamlessly to hot water production.

b. Staging on Additional 2-pipe Heat Pumps (ASHP-2,3)
   1) If the actual load of the heat pump indicates that all compressors of ASHP-1 are running, an additional heat pump (ASHP-2,3) shall be staged on. The BMS shall open the CHW isolation valves associated with that unit and then command it to run in cooling.
   2) The last heat pump (ASHP-2,3) shall be similarly staged on.
   3) The 2-pipe heat pumps shall be subject to equal wear rotation.

   c. Staging off Heat Pumps
      1) If the CHWST setpoint is met, and the actual load indicates that no compressors are running in one of the 2-pipe heat pumps (ASHP-2,3) for 5 minutes, that heat pump shall be staged off and its isolation valves closed.
      2) The other 2-pipe heat pump (ASHP-2,3) shall be similarly staged off.
      3) The BMS shall command ASHP-1 to stop producing chilled water when primary chilled water return (as measured by the heat pump internal sensor and reported by the heat pump internal controls) temperature equals the CHWST setpoint + 0°F

5. Heating Hot Water Production
   a. ASHP-1
      1) The BMS shall command heat pump ASHP-1 to produce heating hot water when the secondary HHW supply temperature exceeds the HHWST setpoint - 8°F
      2) When commanded to provide chilled water, ASHP-1 shall run pumps, fans, and compressors as required to provide heating hot water to the primary HHW loop at the HHWST setpoint.
      3) Simultaneous Heating and Cooling
         a) If any temperature sensor in the chilled water buffer tank is above the CHWST setpoint + 2°F, the heat pump ASHP-1 shall also produce chilled water simultaneously.
         b) Simultaneous chilled water production shall stop when hot water production stops, or when the primary chilled water return temperature (as measured by the heat pump internal sensor and reported by the heat pump internal controls) equals the CHWST setpoint + 0°F, whichever happens first.
(1) If hot water production stops but there is a call to produce chilled water (see logic below), the heat pump shall transition seamlessly to chilled water production.

b. Staging on Additional 2-pipe Heat Pumps (ASHP-2,3)
   1) If the actual load of the heat pump indicates that all compressors of ASHP-1 are running, an additional heat pump (ASHP-2,3) shall be staged on. The BMS shall open the HHW isolation valves associated with that unit and then command it to run in heating.
   2) The last heat pump (ASHP-2,3) shall be similarly staged on.
   3) The 2-pipe heat pumps shall be subject to equal wear rotation.

c. Staging off Heat Pumps
   1) If the HHWST setpoint is met, and the actual load indicates that no compressors are running in one of the 2-pipe heat pumps (ASHP-2,3) for 5 minutes, that heat pump shall be staged off and its isolation valves closed.
   2) The other 2-pipe heat pump (ASHP-2,3) shall be similarly staged off.
   3) The BMS shall command ASHP-1 to stop producing heating hot water when primary hot water return (as measured by the heat pump internal sensor and reported by the heat pump internal controls) temperature equals the HHWST setpoint + 0°F

6. Primary Pumps Control
   a. By internal unit controls, as required.

7. Condenser Fans Control
   a. By internal unit controls, as required.

8. Secondary Hydronic Pumps (CHWP-1,2, HHWP-1,2)
   a. Pumps are sized for 50% of design and shall be controlled on a lead/lag basis with lead pump determined by equal wear rotation logic.
      1) Stage up when lead pump is above 80% speed for 5 minutes.
      2) Stage down when both pumps are at minimum speed for 5 minutes.
   b. Pumps shall be controlled to meet a fixed differential pressure setpoint as measured by dP sensor located near the end of the loop.
      1) There shall be different static pressure setpoints for hot water and chilled water pumps.
      2) Coordinate with balance contractor to determine setpoints.
   c. Pumps shall be enabled if any downstream valve is open more than 10% for 1 minute. Pumps shall be disabled when all downstream valves are less than 5% open for 1 minute.

9. Alarms
   a. Chilled Water Temperature Alarm
      1) If Primary CHW supply temperature is more than 8°F above or below CHWST setpoint for 15 minutes, Level 3 alarm
      2) If Secondary CHW supply temperature is more than 15°F above or below CHWST setpoint for 30 minutes, Level 3 alarm
   b. Hot Water Temperature Alarm:
      1) If Primary HW supply temperature is more than 8°F above or below HWST setpoint for 15 minutes, Level 3 alarm
2) If Secondary HW supply temperature is more than 15°F above or below HWST setpoint for 30 minutes, Level 3 alarm

c. Heat Pump Alarms: Upon activation of the general alarm point by the heat pump’s internal controller
   1) The BMS front end shall display “Heat Pump Equipment Alarm”. This shall be a Level 2 alarm. This shall be displayed on every graphical page associated with heat pump monitoring or control.
   2) BMS front end shall also display the specific type of alarm as transmitted over the network and any additional information about the fault which is provided over the network
   3) These alarms shall NOT be resettable from the BMS front end, per manufacturer recommendation. These alarms require review on-site at the unit’s control interface before being reset.

E. Lab Supply Air Valve, 4-pipe Heating & Cooling Switchover
   1. Lab air valves shall have their own control system and controllers, separate from BAS. Lab controls to communicate to BMS via BACNET.
   2. Lab supply air valves maintain pressurization in the lab via airflow offset control and are also used for maintain temperature control.
   3. Active maximum and minimum setpoints shall vary depending on the time of day and whether the Lab is Occupied or Unoccupied:

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>Occupied</th>
<th>Unoccupied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling maximum</td>
<td>Vcool-max</td>
<td>Vcool-max</td>
</tr>
<tr>
<td>Minimum</td>
<td>Vent-min (6 ACH)</td>
<td>Vent-min (4 ACH)</td>
</tr>
<tr>
<td>Heating maximum</td>
<td>Vheat-max</td>
<td>Vheat-max</td>
</tr>
</tbody>
</table>

a. Lab shall only be considered “Unoccupied” if it is both scheduled unoccupied and has an occupancy sensor that is reading unpopulated (i.e. no occupants currently present in the zone)

4. Temperature Control
   a. When the Zone State is Cooling, the Cooling Loop shall maintain space temperature at the heating setpoint as follows:
      1) From 0% - 25%, the Cooling Loop output shall reset the discharge temperature from the current AHU SAT setpoint to a minimum of Min DAT.
      2) From 26% - 100%, if the discharge air temperature is less than room temperature, the Cooling Loop output shall reset the active airflow setpoint from the minimum airflow setpoint to the maximum cooling airflow setpoint.
   b. When the Zone State is Deadband, the active airflow setpoint shall be the minimum airflow setpoint. All hydronic valves are closed unless the discharge air temperature is below the minimum setpoint (see Paragraph 3.3H.5.e.1)).
   c. When the Zone State is Heating, the Heating Loop shall maintain space temperature at the heating setpoint as follows:
      1) From 0% - 50%, the Heating Loop output shall reset the discharge temperature from the current AHU SAT setpoint to a maximum of MaxΔT above space temperature setpoint.
2) From 51% - 100%, if the discharge air temperature is greater than room temperature plus 5°F, the Heating Loop output shall reset the active airflow setpoint from the minimum airflow setpoint to the maximum heating airflow setpoint.

d. The cooling coil shall be modulated to maintain the discharge temperature at setpoint. In cooling, the switchover isolation valve shall also be open.

1) The heating isolation and control valves shall be closed when the cooling valves are open.
2) In Occupied Mode, the cooling coil shall be modulated to maintain a discharge air temperature no higher than 80°F.
3) When the airflow setpoint is pulse width modulated for TAV operation per Paragraph 3.3B.5, the heating coil shall be locked out and the SAT control loop shall be disabled during the Closed Periods.

e. The heating coil shall be modulated to maintain the discharge temperature at setpoint. In heating, the switchover isolation valve shall also be open. (Directly controlling heating off the zone temperature control loop is not acceptable.)

1) The cooling isolation and control valves shall be closed when the heating valves are open.
2) In Occupied Mode, the heating coil shall be modulated to maintain a discharge air temperature no lower than 50°F.
3) When the airflow setpoint is pulse width modulated for TAV operation per Paragraph 3.3B.5, the heating coil shall be locked out and the SAT control loop shall be disabled during the Closed Periods.

5. Airflow Control

a. The Lab Air Valve damper shall be modulated by a control loop to maintain the measured airflow at the active setpoint Vspt_labsupply.

6. Alarms

a. Low airflow

1) If the measured airflow is less than 70% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 3 alarm.
2) If the measured airflow is less than 50% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 2 alarm.
3) If a zone has an Importance Multiplier of 0 (see Paragraph 3.3A.14.c.1) for its static pressure reset Trim & Respond control loop, low airflow alarms shall be suppressed for that zone.

b. High discharge air temperature

1) If CHW plant is proven on and the discharge air temperature is 15°F more than setpoint for 10 minutes, generate a Level 3 alarm.
2) If CHW plant is proven on and the discharge air temperature is 30°F more than setpoint for 10 minutes, generate a Level 2 alarm.

b. Low discharge air temperature

1) If HHW plant is proven on and the discharge air temperature is 15°F less than setpoint for 10 minutes, generate a Level 3 alarm.
2) If HHW plant is proven on and the discharge air temperature is 30°F less than setpoint for 10 minutes, generate a Level 2 alarm.

d. Leaking damper: If the damper position is 0% and airflow sensor reading is above 10% of Vcool-max for 10 minutes while the fan serving the zone is proven on, generate a Level 4 alarm.
e. Leaking valve: If the valve position is 0% for 15 minutes and discharge air temperature is above AHU SAT by 5°F while the fan serving the zone is proven on, generate a Level 4 alarm.

7. Testing/Commissioning Overrides: Provide software points that interlock to a system level point to
   a. Force zone airflow setpoint Vspt to zero
   b. Force zone airflow setpoint Vspt to Vcool-max
   c. Force zone airflow setpoint Vspt to Vmin
   d. Force zone airflow setpoint Vspt to Vheat-max
   e. Force damper full closed/open
   f. Force heating to off/closed
   g. Reset request-hours accumulator point to zero (provide one point for each reset type listed below)

8. System Requests
   a. Cooling SAT Reset Requests
      1) If the zone temperature exceeds the zone’s cooling setpoint by 5°F for 2 minutes after the suppression period per Paragraph 3.3A.11.h, send 3 Requests,
      2) Else if the zone temperature exceeds the zone’s cooling setpoint by 3°F for 2 minutes after the suppression period per Paragraph 3.3A.11.h, send 2 Requests,
      3) Else if the Cooling Loop is greater than 95%, send 1 Request until the Cooling Loop is less than 85%,
      4) Else if the Cooling Loop is less than 95%, send 0 Requests
   b. Static Pressure Reset Requests
      1) If the measured airflow is less than 50% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 3 Requests,
      2) Else if the measured airflow is less than 70% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 2 Requests,
      3) Else if the damper position is greater than 95%, send 1 Request until the damper position is less than 85%,
      4) Else if the damper position is less than 95%, send 0 Requests
   c. Send Cooling Plant Requests as follows:
      1) If the CHW valve position is greater than 95%, send 1 Request until the CHW valve position is less than 10%
      2) Else if the CHW valve position is less than 95%, send 0 Requests.
   d. Send Heating Plant Requests as follows:
      1) If the HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 10%
      2) Else if the HW valve position is less than 95%, send 0 Requests.

F. Lab Exhaust Air Valve, General
   1. Lab air valves shall have their own control system and controllers, separate from BAS. Lab controls to communicate to BMS via BACNET.
   2. Lab exhaust air valves maintain pressurization in the lab via airflow offset control as required for positive, negative, or neutral control relative to adjacent spaces or outside. This sequence applies to all laboratory exhaust air valves except those serving a fume hood.
3. Lab exhaust air valves maintain face velocity at all times regardless of zone occupancy status.

4. Zones without fume hoods: Active airflow setpoint at the lab air valve shall vary depending on the setpoint at the local supply air valve as follows:
   a. \( V_{\text{spt,labexhaust}} = V_{\text{spt,labsupply}} + \text{offset} \)

5. Zones with fume hoods: Active airflow setpoint at the lab air valve shall vary depending on the setpoint at the local supply air valve and the current airflow setpoint of the fume hoods as follows:
   a. \( V_{\text{spt,labexhaust}} = V_{\text{spt,labsupply}} - V_{\text{spt,labfumehood}} + \text{offset} \)

6. Airflow Control
   a. The Lab Air Valve damper shall be modulated by a control loop to maintain the measured airflow at the active setpoint \( V_{\text{spt,labexhaust}} \).

7. Alarms
   a. Low airflow
      1) If the measured airflow is less than 70% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 3 alarm.
      2) If the measured airflow is less than 50% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 2 alarm.

8. Testing/Commissioning Overrides: Provide software points that interlock to a system level point to
   a. Force zone airflow setpoint \( V_{\text{spt}} \) to zero
   b. Force zone airflow setpoint \( V_{\text{spt}} \) to \( V_{\text{min}} \)
   c. Force damper full closed/open

G. Lab Exhaust Air Valve, Fume Hood
   1. Lab air valves shall have their own control system and controllers, separate from BAS. Lab controls to communicate to BMS via BACNET.
   2. Lab exhaust air valves for fume hoods control airflow to maintain face velocity at the fume hood.
   3. Lab exhaust air valves maintain face velocity at all times regardless of zone occupancy status.
   4. Sash Position Sensor
      a. A sash position sensor mounted on the fume hood shall provide a signal that is linearly proportional to the actual sash position.

5. Face Velocity Control
   a. The fume hood controller shall continually determine the total fume hood open area by monitoring the fume hood sash position via the sash sensor as well as taking account of any fume hood fixed open areas and/or bypass openings.
   b. The fume hood controller shall calculate the required fume hood exhaust airflow necessary to maintain the average face velocity setpoint over the total open area.

6. Airflow Control
   a. The Fume Hood Air Valve damper shall be modulated by a control loop to maintain the measured airflow at the active setpoint \( V_{\text{spt,fumehood}} \).
b. Fume hood controller shall ensure that the required fume hood exhaust to maintain the average face velocity setpoint is always maintained independently of any variations in exhaust system static pressure or any laboratory room conditions such as the ventilation airflow or room static pressure that could otherwise affect the fume hood exhaust airflow.

7. Operator Display Panel
   a. The fume hood controller shall also interface to an operator display panel (ODP) at the designated measurement location on the front of the fume hood.
   b. The ODP shall provide a continuous digital display of the average fume hood face velocity at all times. The fume hood face velocity display shall be the true average face velocity as calculated by the fume hood controller based upon the actual measured fume hood exhaust airflow and the total fume hood total open area.
   c. The ODP shall also include separate colored lights that shall illuminate to indicate fume hood operations status:
      1) Green- Proper face velocity
      2) Yellow- Marginal face velocity
      3) Red- Face Velocity Alarm Conditions
   d. The ODP shall also contain an audible alarm device that responds to face velocity alarm conditions and the ODP digital display shall change to "low face velocity" or "high face velocity" appropriate to the alarm condition.
   e. A silence push button at the ODP shall allow the user to silence the audible alarm which shall then remain silent until a subsequent face velocity alarm occurs.

8. Purge Mode
   a. The ODP shall also provide an emergency purge pushbutton which shall allow a user to increase fume hood exhaust airflow to the maximum amount for a designated period of time as required by lab safety standards.
   b. The initial setting for the emergency purge time shall be 1 minute.
   c. After the designated emergency purge time has expired, the fume hood exhaust shall automatically reset to a lower level to prevent excessive demand on the exhaust system.
   d. Emergency purge mode shall be cancellable at any time by depressing the emergency purge button a second time.
   e. The ODP shall sound its audible alarm device whenever the emergency purge mode of operation is activated.

9. Over-Opened Sash
   a. The ODP shall also provide an audible sash open alert feature that shall caution users whenever the fume hood sash exceeds a predetermined height.
   b. The audible alert shall consist of a series of quick "chirps" that continue until the sash is reduced to an acceptable height.

10. Alarms
    a. Low Face Velocity
        1) If the calculated face velocity is below its alarm threshold and generating an alarm at the ODP, a Level 2 alarm shall also be generated at the BMS.
    b. Low airflow
        1) If the measured airflow is less than 70% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 3 alarm.
        2) If the measured airflow is less than 50% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 2 alarm.
H. **VAV Supply Terminal Unit, 4-pipe Heating & Cooling Switchover**

1. This is a Thermal Control Zone device.
   a. See Generic Thermal Control Zones (Paragraph 3.3B) for setpoints, loops, control modes, alarms, etc.
   b. See Paragraph 3.3B.3 for calculation of zone minimum outdoor air requirements.
   c. See Paragraph 3.3B.4 for logic to reset active zone minimum airflow $V_{min^*}$.

2. See Paragraph 3.1H.1 for zone minimum airflow setpoint $V_{min}$, zone cooling maximum airflow setpoint $V_{cool-max}$, and zone heating maximum airflow setpoint $V_{heat-max}$.

3. See Paragraph 3.1H.2 for maximum heating DAT rise $Max\Delta T$.

4. Active maximum and minimum setpoints shall vary depending on the Mode of the Zone Group the zone is a part of, in accordance with the following table:

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>Occupied</th>
<th>Cool-down</th>
<th>Setup</th>
<th>Warm-up</th>
<th>Setback</th>
<th>Unoccupied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling maximum</td>
<td>$V_{cool-max}$</td>
<td>$V_{cool-max}$</td>
<td>$V_{cool-max}$</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Minimum</td>
<td>$V_{min^*}$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Heating maximum</td>
<td>$Max(V_{heat-max}, V_{min^*})$</td>
<td>$V_{heat-max}$</td>
<td>0</td>
<td>$V_{cool-max}$</td>
<td>$V_{cool-max}$</td>
<td>0</td>
</tr>
</tbody>
</table>

5. Control logic is depicted schematically in the figure below and described in the following sections. Relative levels of various setpoints are depicted for Occupied Mode operation.
a. When the Zone State is Cooling, the Cooling Loop shall maintain space temperature at the cooling setpoint as follows:
   1) From 0% - 25%, the Cooling Loop output shall reset the discharge temperature from the current AHU SAT setpoint to a minimum of Min DAT.
   2) From 26% - 100%, if the discharge air temperature is less than room temperature, the Cooling Loop output shall reset the active airflow setpoint from the minimum airflow setpoint to the maximum cooling airflow setpoint.

b. When the Zone State is Deadband, the active airflow setpoint shall be the minimum airflow setpoint. Hot water valve is closed unless the discharge air temperature is below the minimum setpoint (see Paragraph 3.3H.5.e.1)).

c. When the Zone State is Heating, the Heating Loop shall maintain space temperature at the heating setpoint as follows:
   1) From 0% - 50%, the Heating Loop output shall reset the discharge temperature from the current AHU SAT setpoint to a maximum of MaxΔT above space temperature setpoint.
   2) From 51% - 100%, if the discharge air temperature is greater than room temperature plus 5°F, the Heating Loop output shall reset the active airflow setpoint from the minimum airflow setpoint to the maximum heating airflow setpoint.

d. The cooling coil shall be modulated to maintain the discharge temperature at setpoint. In cooling, the switchover isolation valve shall also be open.
   1) The heating isolation and control valves shall be closed when the cooling valves are open.
   2) In Occupied Mode, the cooling coil shall be modulated to maintain a discharge air temperature no higher than 80°F.
   3) When the airflow setpoint is pulse width modulated for TAV operation per Paragraph 3.3B.5, the heating coil shall be locked out and the SAT control loop shall be disabled during the Closed Periods.

e. The heating coil shall be modulated to maintain the discharge temperature at setpoint. In heating, the switchover isolation valve shall also be open. (Directly controlling heating off the zone temperature control loop is not acceptable.)
   1) The cooling isolation and control valves shall be closed when the heating valves are open.
   2) In Occupied Mode, the heating coil shall be modulated to maintain a discharge air temperature no lower than 50°F.
   3) When the airflow setpoint is pulse width modulated for TAV operation per Paragraph 3.3B.5, the heating coil shall be locked out and the SAT control loop shall be disabled during the Closed Periods.

f. The VAV damper shall be modulated by a control loop to maintain the measured airflow at the active setpoint Vspt.

6. Alarms
   a. Low airflow
      1) If the measured airflow is less than 70% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 3 alarm.
      2) If the measured airflow is less than 50% of setpoint while setpoint is greater than zero for 5 minutes, generate a Level 2 alarm.
      3) If a zone has an Importance Multiplier of 0 (see Paragraph 3.3A.14.c.1) for its static pressure reset Trim & Respond control loop, low airflow alarms shall be suppressed for that zone.
b. High discharge air temperature
   1) If CHW plant is proven on and the discharge air temperature is 15°F more than setpoint for 10 minutes, generate a Level 3 alarm.
   2) If CHW plant is proven on and the discharge air temperature is 30°F more than setpoint for 10 minutes, generate a Level 2 alarm.

c. Low discharge air temperature
   1) If HHW plant is proven on and the discharge air temperature is 15°F less than setpoint for 10 minutes, generate a Level 3 alarm.
   2) If HHW plant is proven on and the discharge air temperature is 30°F less than setpoint for 10 minutes, generate a Level 2 alarm.

d. Airflow sensor calibration: If the fan serving the zone has been off for 10 minutes and airflow sensor reading is greater than 10% of Vcool-max, generate a Level 3 alarm.

e. Leaking damper: If the damper position is 0% and airflow sensor reading is above 10% of Vcool-max for 10 minutes while the fan serving the zone is proven on, generate a Level 4 alarm.

f. Leaking valve: If the valve position is 0% for 15 minutes and discharge air temperature is above AHU SAT by 5°F while the fan serving the zone is proven on, generate a Level 4 alarm.

7. Testing/Commissioning Overrides: Provide software points that interlock to a system level point to
   a. Force zone airflow setpoint Vspt to zero
   b. Force zone airflow setpoint Vspt to Vcool-max
   c. Force zone airflow setpoint Vspt to Vmin
   d. Force zone airflow setpoint Vspt to Vheat-max
   e. Force damper full closed/open
   f. Force heating to off/closed
   g. Reset request-hours accumulator point to zero (provide one point for each reset type listed below)

8. System Requests
   a. Cooling SAT Reset Requests
      1) If the zone temperature exceeds the zone’s cooling setpoint by 5°F for 2 minutes after the suppression period per Paragraph 3.3A.11.h, send 3 Requests,
      2) Else if the zone temperature exceeds the zone’s cooling setpoint by 3°F for 2 minutes after the suppression period per Paragraph 3.3A.11.h, send 2 Requests,
      3) Else if the Cooling Loop is greater than 95%, send 1 Request until the Cooling Loop is less than 85%,
      4) Else if the Cooling Loop is less than 95%, send 0 Requests

   b. Static Pressure Reset Requests
      1) If the measured airflow is less than 50% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 3 Requests,
      2) Else if the measured airflow is less than 70% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 2 Requests,
      3) Else if the damper position is greater than 95%, send 1 Request until the damper position is less than 85%,
      4) Else if the damper position is less than 95%, send 0 Requests
c. Send Cooling Plant Requests as follows:
   1) If the CHW valve position is greater than 95%, send 1 Request until the CHW valve position is less than 10%
   2) Else if the CHW valve position is less than 95%, send 0 Requests.

d. Send Heating Plant Requests as follows:
   1) If the HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 10%
   2) Else if the HW valve position is less than 95%, send 0 Requests.

I. Typical Cooling-only FCU
   1. See Generic Thermal Control Zones (Paragraph 3.1B) for setpoints, loops, control modes, alarms, etc.
   2. Fan coil units shall have their own distinct occupancy schedule, initially 24/7. The fancoil unit and the Cooling Loop shall be enabled whenever its zone is in Occupied Mode. Otherwise, the unit shall be off, the control loop disabled and the coil valve closed.
   3. Discharge Air Temperature Setpoint and Control
      a. If the Cooling Loop signal is more than 5%, the unit shall operate in cooling
         1) A PI loop shall modulate the CHW control valve to maintain SA Temperature at setpoint. Mapping valve position directly to the Cooling Loop signal is not acceptable.
      b. There is no Heating Loop for these units.
      c. If the Cooling Loop signal is less than 5% (i.e. unit is in deadband), SA temperature control shall be suspended. CHW control valve shall be closed.
      d. The cooling SA temp setpoint and offset shall be independently adjustable for each unit.
   4. Fan Speed and Control
      a. The fan shall run whenever the unit is enabled and the cooling loop signal is greater than 0%.
      b. Maximum fan speed shall be that which provides the scheduled airflow.
      c. Minimum fan speed shall be 20% of maximum, or the minimum controllable fan speed.
      d. If cooling loop is equal to zero, fan shall be off. When the Cooling Loop is greater than zero, the fan speed shall be the minimum.
      e. The fan speed shall reset from minimum to maximum as the Cooling Loop goes from 0% to 100%.
   5. Alarms
      a. Maintenance interval alarm when fan has operated for more than 1500 hours: Level 5. Reset interval counter when alarm is acknowledged.
      b. Fan alarm is indicated by the status input being different from the output command after a period of 15 seconds after a change in output status.
         1) Commanded on, status off: Level 2
         2) Commanded off, status on: Level 4
      c. High supply air temperature (more than 5°F above setpoint) off cooling coils when coil control loop is active for longer than 5 minutes: Level 3.
      d. When CHW valve is commanded closed, supply air temperature more than 3°F below space temperature for longer than 5 minutes: Level 4, indicating a potential leaking control valve
e. Drip pan sensor: If the moisture sensor in the condensate pan detects moisture for longer than one minute, lock out the cooling valve and set a Level 3 alarm indicating that fancoil cooling is disabled for that zone. Release the cooling coil lockout when moisture is no longer detected at the sensor.

6. System Requests
   a. Send Cooling Plant Requests as follows:
      1) If the CHW valve position is greater than 95%, send 1 Request until the CHW valve position is less than 10%
      2) Else if the CHW valve position is less than 95%, send 0 Requests.

J. Air Handling Unit System Modes
   1. AHU system Modes are the same as the Mode of the Zone Group served by the system. When Zone Groups served by a single air handling system are in different modes, the following hierarchy applies (highest one sets AHU mode).
      a. Occupied Mode
      b. Cool-down Mode
      c. Setup Mode
      d. Warm-up Mode
      e. Setback Mode
      f. Freeze Protection Setback Mode
      g. Unoccupied Mode

K. Multiple Zone Recirculating VAV Air Handling Unit
   1. Supply Fan Control
      a. Supply Fan Start/Stop
         1) Supply fan shall run continuously as it serves Lab zones in addition to non-lab zones.
      b. Supply Airflow Measurement
         1) Totalize current airflow rate from VAV boxes and Lab supply air valves to a software point \( V_{ps} \) and display this sum-of-zones airflow near the discharge duct on AHU graphic.
         2) When economizer is disabled, display measured outdoor airflow rate near intake on AHU graphic. When economizer is enabled, hide this display as it will not be accurate.
         3) If the AHU has a total supply (not outdoor air) airflow measurement station, display the AFMS airflow rate adjacent to the sum-of-zone airflow rate.
            a) If the airflow measured by the AFMS exceeds the sum-of-zones airflow by more than 10% for more than five minutes, display the difference with the legend “Potential Leakage”. (If the difference is less than 10%, then this value shall not display.)
      c. Static Pressure Setpoint Reset
         1) See Paragraph 3.2E.1.a for Max_DSP, the maximum duct static pressure setpoint.
         2) Static pressure setpoint shall be reset using Trim & Respond logic (see Paragraph 3.3A.14) with the following parameters. Parameters should be adjusted if needed during commissioning to provide stable control (i.e. slow, smooth cycling of the setpoint).
d. Static Pressure Control

1) Supply fan speed is controlled to maintain duct static pressure at setpoint when the fan is proven on. If necessary for system stability, provide multiple sets of gains, with as a function of system load (e.g. as indicated by supply fan airflow rate, the area of the Zone Groups that are occupied, etc.) to provide consistent, smooth control response under a range of conditions.

2. Supply Air Temperature Control

a. The supply air temperature control loop sequences coils and dampers to maintain supply air temperature at setpoint. This control loop is enabled when the supply fan is proven on, and disabled with output set to Deadband (no heating, minimum economizer) otherwise.

b. Supply Air Temperature Setpoint

1) See Paragraph 3.1K for minimum and maximum cooling supply air temperature setpoints Min_ClgsAT and Max_ClgsAT, and for the outdoor air temperature range by which the SAT setpoint is reset (OAT_Min, OAT_Max).

2) During Occupied Mode and Setup Mode: Setpoint shall be reset from Min_ClgsAT when the outdoor air temperature is OAT_Max or higher, proportionally up to T-max when the outdoor air temperature is OAT_Min or lower.

a) T-max shall be reset between Min_ClgsAT and Max_ClgsAT using Trim & Respond logic (see Paragraph 3.3A.14) with the following parameters.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>AHU Coils &amp; Dampers</td>
</tr>
<tr>
<td>SP_0</td>
<td>SP_{max}</td>
</tr>
<tr>
<td>SP_{min}</td>
<td>Min_ClgsAT (3.1K.a)</td>
</tr>
<tr>
<td>SP_{max}</td>
<td>Max_ClgsAT (3.1K.b)</td>
</tr>
<tr>
<td>T_d</td>
<td>10 minutes</td>
</tr>
<tr>
<td>T</td>
<td>2 minutes</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>Zone Cooling SAT Requests</td>
</tr>
<tr>
<td>SP_{trim}</td>
<td>+0.3°F</td>
</tr>
<tr>
<td>SP_{res}</td>
<td>-0.4°F</td>
</tr>
<tr>
<td>SP_{res-max}</td>
<td>-1.2°F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Supply Fan</td>
</tr>
<tr>
<td>SP_0</td>
<td>0.5 inches</td>
</tr>
<tr>
<td>SP_{min}</td>
<td>0.1 inches</td>
</tr>
<tr>
<td>SP_{max}</td>
<td>Max_DSP</td>
</tr>
<tr>
<td>T_d</td>
<td>10 minutes</td>
</tr>
<tr>
<td>T</td>
<td>2 minutes</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>Zone Static Pressure Reset Requests</td>
</tr>
<tr>
<td>SP_{trim}</td>
<td>-0.05 inches</td>
</tr>
<tr>
<td>SP_{res}</td>
<td>+0.06 inches</td>
</tr>
<tr>
<td>SP_{res-max}</td>
<td>+0.18 inches</td>
</tr>
</tbody>
</table>
The net result of this SAT reset strategy is depicted in the chart below:

3) During Cool-Down Mode: Setpoint shall be Min_ClgSAT.
4) During Warm-Up and Setback Modes: Setpoint shall be 95°F.

c. Supply air temperature shall be controlled to setpoint using a control loop whose output is mapped to sequence the hot water/heat recovery valve, outdoor air damper, and return air damper as shown in the diagram below.

1) Economizer damper maximum (MaxOA-P) position is limited for economizer high limit lockout (see Paragraph 3.3K.5.d).
2) For units with a separate minimum outdoor air damper: MinOA-P is 0% and MaxRA-P is modulated to maintain minimum outdoor airflow (see Paragraph 3.3K.4.c).
3) The points of transition along the x-axis shown and described below are representative. Separate gains shall be provided for each section of the control map (hot water, economizer, chilled water), that are determined by DDC Contractor to provide stable control. DDC Contractor shall also adjust the precise value of the x-axis thresholds shown in the figure to provide stable control.
3. Minimum Outdoor Airflow Setpoint
   a. Minimum outdoor airflow setpoints, for California Title 24 ventilation:
      1) See Paragraph 3.1K.2 for system minimum outdoor air setpoints AbsMinOA and DesMinOA
      2) See Paragraph 3.3B.3.b for zone outdoor air rates Zone-Abs-OA-min and Zone-Des-OA-min.
      3) Effective outdoor air absolute minimum and design minimum setpoints are recalculated continuously based on the Mode of the zones being served.
         a) AbsMinOA* is the sum of Zone-Abs-OA-min for all non-lab zones in all Zone Groups that are in Occupied Mode plus the exhaust airflow rate as measured at the main exhaust fans, but shall be no larger than the scheduled absolute minimum outdoor airflow, AbsMinOA.
         b) DesMinOA* is the sum of Zone-Des-OA-min for all non-lab zones in all Zone Groups that are in Occupied Mode plus the exhaust airflow rate as measured at the main exhaust fans, but shall be no larger than the scheduled design minimum outdoor airflow, DesMinOA.
      4) Minimum outdoor air setpoint MinOAsp: Reset MinOAsp based on the highest zone CO₂ control loop signal, from AbsMinOA* at 50% signal to DesMinOA* at 100% signal.

4. Minimum Outdoor Air Control
   a. Minimum outdoor air control loop is enabled when the supply fan is proven on and the AHU is in Occupied Mode. It is disabled and output set to zero otherwise.
   b. The outdoor airflow rate shall be maintained at the minimum outdoor air setpoint MinOAsp by a reverse-acting control loop whose output is 0% - 100%.
      1) From 0% to 50% loop output, reset the minimum outdoor air damper position from 0% to 100%.
      2) Loop output greater than 50% is used when return air damper minimum outdoor air control logic (see below) is active.
c. Return Air Damper Control for Outdoor Air

1) Return air damper control for outdoor air is enabled and disabled based on supply fan speed and the positions of the economizer and minimum outdoor air dampers.
   a) Reset MinEcon from 5% at maximum supply fan speed proportionally to 80% at minimum supply fan speed.
   b) Return air damper control for outdoor air is enabled when the minimum outdoor air damper is 100% open and the economizer damper position is less than MinEcon for five minutes.
   c) Return air damper control for outdoor air is disabled when the minimum outdoor air damper is less than 100% open or the economizer damper position is 10% greater than MinEcon for five minutes.

2) When this logic is enabled, the maximum return damper position, MaxRA-P, is modulated from 100% to 0% as the minimum outdoor air control loop signal (Paragraph 3.3K.4.b) rises from 50% to 100%.

3) When this logic is disabled, the return air damper shall be controlled by the supply air temperature control logic (see Paragraph 3.3K.2.c).

5. Economizer High Limit Lockout
   a. When economizer is enabled, MaxOA-P = 100%.
   b. The normal sequencing of the economizer dampers (above) shall be disabled when outdoor conditions exceed the high limit lockout as specified in Paragraph 3.1K.3.
   c. Once the economizer is disabled, it shall not be re-enabled within 10 minutes, and vice versa.
   d. The economizer is disabled according to the following procedure:
      1) Return air damper shall be fully opened
      2) Wait 15 seconds, then set MaxOA-P equal to MinOA-P.
      3) Wait 3 minutes, then release return air damper for minimum outdoor air control.

6. Return Fan Control – Airflow Tracking
   a. Return fan operates whenever associated non-lab VAV boxes are in a mode other than Unoccupied. If all non-lab VAV zones are Unoccupied, indicating that there is no air available to recirculate, return fan shall be off.
   b. Return fan speed shall be controlled to maintain return airflow equal to supply airflow less the differential S-R-CFM-DIFF determined per Paragraph 3.2E.1.c.

7. Freeze Protection
   a. If the supply air temperature drops below 40°F for 5 minutes, send two (or more, as required to ensure that heating plant is active) Heating Plant Requests, override the outdoor air damper to the minimum position, and modulate the heating coil to maintain a supply air temperature of at least 42°F. Disable this function when supply air temperature rises above 45°F for 5 minutes.
   b. If the supply air temperature drops below 38°F for 5 minutes, fully close both the economizer damper and the minimum outdoor air damper for one hour, and set a Level 3 alarm noting that minimum ventilation was interrupted. After one hour, the unit shall resume minimum outdoor air ventilation and enter the previous stage of freeze protection (see Paragraph 3.3K.7.a).
c. If supply air temperature drops below 38°F for 15 minutes or below 34°F for 5 minutes, shut down supply and return/relief fan(s), close outdoor air damper. Also send two (or more, as required to ensure that heating plant is active) Heating Plant Requests, modulate the heating coil to maintain the higher of the supply air temperature or the mixed air temperature at 80°F, and set a Level 2 alarm indicating the unit is shut down by freeze protection.

1) If a freeze protection shutdown is triggered by a low air temperature sensor reading, it shall remain in effect until it is reset by the Operator.

8. Alarms
   a. Maintenance interval alarm when fan has operated for more than 1,500 hours: Level 5. Reset interval counter when alarm is acknowledged.
   b. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.
      1) Commanded on, status off: Level 2
      2) Commanded off, status on: Level 4
   c. Filter pressure drop exceeds alarm limit: Level 5. The alarm limit shall vary with total airflow (if available; use fan speed if total airflow is not known) as follows:

\[ DP_x = DP_{100} (x)^{1.4} \]

where \( DP_{100} \) is the high limit pressure drop at design airflow (determine limit from filter manufacturer) and \( DP_x \) is the high limit at the current airflow rate (or speed signal) \( x \), where \( x \) is a percentage of design maximum. For instance, the setpoint at 50% of design airflow would be \((.5)^{1.4}\) or 38% of the design high limit pressure drop.

d. High building pressure (more than 0.10"): Level 3

e. Low building pressure (less than 0.0", i.e. negative): Level 4

9. Automatic Fault Detection and Diagnostics

a. AFDD conditions are evaluated continuously and separately for each operating air handling unit.

b. The Operating State (OS) of each AHU shall be defined by the commanded positions of the heating coil control valve, cooling coil control valve, and economizer damper in accordance with the following table and corresponding graphic.

<table>
<thead>
<tr>
<th>Operating State</th>
<th>Heat Recovery Valve Position (Heating)</th>
<th>Heat Recovery Valve Position (Cooling)</th>
<th>Outdoor Air Damper Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1: Heating</td>
<td>&gt; 0</td>
<td>= 0</td>
<td>= MIN</td>
</tr>
<tr>
<td>#2: Free Cooling, Modulating OA</td>
<td>= 0</td>
<td>= 0</td>
<td>MIN &lt; X &lt; 100%</td>
</tr>
<tr>
<td>#3: Mechanical + Economizer</td>
<td>= 0</td>
<td>&gt; 0</td>
<td>= 100%</td>
</tr>
<tr>
<td>#4: Mechanical Cooling, Min OA</td>
<td>= 0</td>
<td>&gt; 0</td>
<td>= MIN</td>
</tr>
<tr>
<td>#5: Unknown</td>
<td>No other OS applies</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
c. The following points must be available to the AFDD routines for each AHU:

1) SAT = Supply air temperature
2) MAT = Mixed air temperature
3) RAT = Return air temperature
4) OAT = Outdoor air temperature
5) DSP = Duct static pressure
6) SATSP = supply air temperature setpoint
7) DSPSP = duct static pressure setpoint
8) HC = heating coil valve position command; 0% ≤ HC ≤ 100%
9) CC = cooling coil valve position command; 0% ≤ CC ≤ 100%
10) FS = fan speed command; 0% ≤ FS ≤ 100%
11) CCET = cooling coil entering temperature; depending on the AHU configuration this could be the MAT or a separate sensor for this specific purpose.
12) CCLT = cooling coil leaving temperature; depending on the AHU configuration this could be the SAT or a separate sensor for this specific purpose.
13) HCET = heating coil entering temperature; depending on the AHU configuration this could be the MAT or a separate sensor for this specific purpose.
14) HCLT = heating coil leaving temperature; depending on the AHU configuration this could be the SAT or a separate sensor for this specific purpose.

d. The following values must be continuously calculated by the AFDD routines for each AHU:

1) Five minute rolling averages with 1 minute sampling time of the following point values; operator shall have the ability to adjust the averaging window and sampling period for each point independently
   a) SAT\textsuperscript{AVG} = rolling average of supply air temperature
   b) MAT\textsuperscript{AVG} = rolling average of mixed air temperature
   c) RAT\textsuperscript{AVG} = rolling average of return air temperature
d) OAT\textsubscript{AVG} = rolling average of outdoor air temperature

e) DSP\textsubscript{AVG} = rolling average of duct static pressure

f) CCET\textsubscript{AVG} = rolling average of cooling coil entering temperature
g) CCLT\textsubscript{AVG} = rolling average of cooling coil leaving temperature

h) HCET\textsubscript{AVG} = rolling average of heating coil entering temperature

i) HCLT\textsubscript{AVG} = rolling average of heating coil leaving temperature

2) \%OA = actual outdoor air fraction as a percentage = \frac{MAT - RAT}{OAT - RAT} or per airflow measurement station if available.

3) \%OA\textsubscript{MIN} = Active minimum OA setpoint (MinOAsp) divided by actual total airflow (from sum of VAV box flows, or by airflow measurement station) as a percentage.

4) \Delta OS = number of changes in Operating State during the previous 60 minutes (moving window)

e. The following internal variables shall be defined for each AHU. All parameters are adjustable by the operator, with initial values as given below:

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>\Delta T\textsubscript{SF}</td>
<td>Temperature rise across supply fan</td>
<td>2° F</td>
</tr>
<tr>
<td>\Delta T\textsubscript{MIN}</td>
<td>Minimum difference between OAT and RAT to evaluate economizer error conditions (FC#6)</td>
<td>10° F</td>
</tr>
<tr>
<td>\varepsilon\textsubscript{SAT}</td>
<td>Temperature error threshold for SAT sensor</td>
<td>2° F</td>
</tr>
<tr>
<td>\varepsilon\textsubscript{RAT}</td>
<td>Temperature error threshold for RAT sensor</td>
<td>2° F</td>
</tr>
<tr>
<td>\varepsilon\textsubscript{MAT}</td>
<td>Temperature error threshold for MAT sensor</td>
<td>5° F</td>
</tr>
<tr>
<td>\varepsilon\textsubscript{OAT}</td>
<td>Temperature error threshold for OAT sensor</td>
<td>2° F if local sensor @ unit. 5° F if global sensor.</td>
</tr>
<tr>
<td>\varepsilon\textsubscript{F}</td>
<td>Airflow error threshold</td>
<td>30%</td>
</tr>
<tr>
<td>\varepsilon\textsubscript{VFDSPD}</td>
<td>VFD speed error threshold</td>
<td>5%</td>
</tr>
<tr>
<td>\varepsilon\textsubscript{DSP}</td>
<td>Duct static pressure error threshold</td>
<td>0.1&quot;</td>
</tr>
<tr>
<td>\varepsilon\textsubscript{CCET}</td>
<td>Cooling coil entering temperature sensor error. Equal to \varepsilon\textsubscript{MAT} or dedicated sensor error</td>
<td>Varies, See Description</td>
</tr>
<tr>
<td>\varepsilon\textsubscript{CCLT}</td>
<td>Cooling coil leaving temperature sensor error. Equal to \varepsilon\textsubscript{SAT} or dedicated sensor error</td>
<td></td>
</tr>
<tr>
<td>\varepsilon\textsubscript{HCET}</td>
<td>Heating coil entering temperature sensor error; equal to \varepsilon\textsubscript{MAT} or dedicated sensor error</td>
<td></td>
</tr>
<tr>
<td>\varepsilon\textsubscript{HCLT}</td>
<td>Heating coil leaving temperature sensor error. Equal to \varepsilon\textsubscript{SAT} or dedicated sensor error</td>
<td></td>
</tr>
<tr>
<td>\Delta OS\textsubscript{MAX}</td>
<td>Maximum number of changes in Operating State during the previous 60 minutes</td>
<td>7</td>
</tr>
<tr>
<td>Variable Name</td>
<td>Description</td>
<td>Default Value</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>ModeDelay</td>
<td>Time in minutes to suspend Fault Condition evaluation after a change in Mode</td>
<td>30</td>
</tr>
<tr>
<td>AlarmDelay</td>
<td>Time in minutes to that a Fault Condition must persist before triggering an alarm</td>
<td>15</td>
</tr>
<tr>
<td>TestModeDelay</td>
<td>Time in minutes that Test Mode is enabled</td>
<td>120</td>
</tr>
</tbody>
</table>

The following are potential Fault Conditions that can be evaluated by the AFDD routines. If the equation statement is true, then the specified fault condition exists. The Fault Conditions to be evaluated at any given time will depend on the Operating State of the AHU.

<table>
<thead>
<tr>
<th>FC #1</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DSP &lt; DSPSP - $\varepsilon_{DSP}$ and VFDSPD $\geq$ 99% - $\varepsilon_{VFDSPD}$</td>
<td>Duct static pressure is too low with fan at full speed</td>
<td>Problem with VFD, Mechanical problem with fan, SAT Setpoint too high (too much zone demand)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FC #2</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$MAT_{AVG} + \varepsilon_{MAT} &lt; \min[(RAT_{AVG} - \varepsilon_{RAT}), (OAT_{AVG} - \varepsilon_{OAT})]$</td>
<td>MAT too low; should be between OAT and RAT</td>
<td>RAT sensor error, MAT sensor error, OAT sensor error</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FC #3</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$MAT_{AVG} - \varepsilon_{MAT} &gt; \max[(RAT_{AVG} + \varepsilon_{RAT}), (OAT_{AVG} + \varepsilon_{OAT})]$</td>
<td>MAT too high; should be between OAT and RAT</td>
<td>RAT sensor error, MAT sensor error, OAT sensor error</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FC #4</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\Delta OS &gt; \Delta OS_{MAX}$</td>
<td>Too many changes in Operating State</td>
<td>Unstable control due to poorly tuned loop or mechanical problem</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FC #5</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
</table>
|       | $SAT_{AVG} + \varepsilon_{SAT} \leq MAT_{AVG} - \varepsilon_{MAT} + \Delta T_{SF}$ | SAT too low; should be higher than MAT | SAT sensor error, MAT sensor error, Cooling coil valve leaking or stuck open, Heating coil valve stuck closed or actuator failure, Fouled or undersized heating coil, HW temperature too low or HW unavailable.
<table>
<thead>
<tr>
<th>FC #</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC #6</td>
<td>$</td>
<td>\overline{RAT_{AVG}} - \overline{OAT_{AVG}}</td>
<td>\geq \Delta T_{MIN}$ and $</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Leaking or stuck economizer damper or actuator</td>
</tr>
<tr>
<td>FC #7</td>
<td>$\overline{SAT_{AVG}} &lt; \overline{SAT_{SP}} - \varepsilon_{SAT}$ and $\overline{HC} \geq 99%$</td>
<td>SAT too low in full heating</td>
<td>SAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cooling coil valve leaking or stuck open</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Heating coil valve stuck closed or actuator failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fouled or undersized heating coil</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>HW temperature too low or HW unavailable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Leaking or stuck economizer damper or actuator</td>
</tr>
<tr>
<td>FC #8</td>
<td>$</td>
<td>\overline{SAT_{AVG}} - \overline{\Delta T_{SF}} - \overline{MAT_{AVG}}</td>
<td>&gt; \sqrt{\varepsilon_{SAT}^2 + \varepsilon_{MAT}^2}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cooling coil valve leaking or stuck open</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Heating coil valve leaking or stuck open</td>
</tr>
<tr>
<td>FC #9</td>
<td>$\overline{OAT_{AVG}} - \varepsilon_{OAT} &gt; \overline{SAT_{SP}} - \overline{\Delta T_{SF}} + \varepsilon_{SAT}$</td>
<td>OAT is too high for free cooling without additional mechanical cooling</td>
<td>SAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cooling coil valve leaking or stuck open</td>
</tr>
<tr>
<td>FC #10</td>
<td>$</td>
<td>\overline{MAT_{AVG}} - \overline{OAT_{AVG}}</td>
<td>&gt; \sqrt{\varepsilon_{MAT}^2 + \varepsilon_{OAT}^2}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OAT sensor error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Leaking or stuck economizer damper or actuator</td>
</tr>
<tr>
<td>FC #11</td>
<td>$\overline{OAT_{AVG}} + \varepsilon_{OAT} &lt; \overline{SAT_{SP}} - \overline{\Delta T_{SF}} - \varepsilon_{SAT}$</td>
<td>OAT is too low for 100% OA cooling</td>
<td></td>
</tr>
<tr>
<td>FC #12</td>
<td>Possible Diagnosis</td>
<td>Equation</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------</td>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td></td>
<td>SAT sensor error</td>
<td>SAT$^\text{AVG}$ - $\varepsilon_{SAT} - \Delta T_{SF} \geq$ MAT$^\text{AVG}$ + $\varepsilon_{MAT}$</td>
<td>SAT too high; should be less than MAT</td>
</tr>
<tr>
<td></td>
<td>OAT sensor error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heating coil valve leaking or stuck open</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leaking or stuck economizer damper or actuator</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAT sensor error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MAT sensor error</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cooling coil valve stuck closed or actuator failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fouled or undersized cooling coil</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHW temperature too high or CHW unavailable</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heating coil valve leaking or stuck open</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FC #13</th>
<th>Possible Diagnosis</th>
<th>Equation</th>
<th>Description</th>
<th>Applies to OS #3, #4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SAT sensor error</td>
<td>SAT$^\text{AVG}$ &gt; SAT$^\text{SP}$ + $\varepsilon_{SAT}$ and CC $\geq$ 99%</td>
<td>SAT too high in full cooling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cooling coil valve stuck closed or actuator failure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fouled or undersized cooling coil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHW temperature too high or CHW unavailable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heating coil valve leaking or stuck open</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### BUILDING AUTOMATION SEQUENCES OF OPERATIONS

#### C-4016 New Science Building - DSA Increment 2

<table>
<thead>
<tr>
<th>FC #</th>
<th>Equation</th>
<th>Description</th>
<th>Possible Diagnosis</th>
<th>Applies to OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>[\text{CCET}<em>{\text{AVG}} - \text{CCLT}</em>{\text{AVG}} \geq \sqrt{\varepsilon_{\text{CCET}}^2 + \varepsilon_{\text{CCLT}}^2 + \Delta T_{\text{SF}}}^*]</td>
<td>Temperature drop across inactive cooling coil</td>
<td>CCET sensor error, CCLT sensor error, Cooling coil valve stuck open or leaking.</td>
<td>OS #1, #2</td>
</tr>
<tr>
<td>15</td>
<td>[\text{HCLT}<em>{\text{AVG}} - \text{HCET}</em>{\text{AVG}} \geq \sqrt{\varepsilon_{\text{HCET}}^2 + \varepsilon_{\text{HCLT}}^2 + \Delta T_{\text{SF}}}^*]</td>
<td>Temperature rise across inactive heating coil</td>
<td>HCET sensor error, HCLT sensor error, Heating coil valve stuck open or leaking.</td>
<td>OS #2 - #4</td>
</tr>
</tbody>
</table>

10. A subset of all potential fault conditions is evaluated by the AFDD routines. The set of applicable fault conditions depends on the Operating State of the AHU:

1) In OS #1 (Heating), the following Fault Conditions shall be evaluated:
   - a) FC#1: Duct static pressure is too low with fan at full speed
   - b) FC#2: MAT too low; should be between RAT and OAT
   - c) FC#3: MAT too high; should be between RAT and OAT
   - d) FC#4: Too many changes in Operating State
   - e) FC#5: SAT too low; should be higher than MAT
   - f) FC#6: OA fraction is too low or too high; should equal %OAMIN
   - g) FC#7: SAT too low in full heating
   - h) FC#14: Temperature drop across inactive cooling coil

2) In OS#2 (Modulating Economizer), the following Fault Conditions shall be evaluated:
   - a) FC#1: Duct static pressure is too low with fan at full speed
   - b) FC#2: MAT too low; should be between RAT and OAT
   - c) FC#3: MAT too high; should be between RAT and OAT
   - d) FC#4: Too many changes in Operating State
   - e) FC#8: SAT and MAT should be approximately equal
   - f) FC#9: OAT is too high for free cooling without mechanical cooling
   - g) FC#14: Temperature drop across inactive cooling coil
   - h) FC#15: Temperature rise across inactive heating coil

3) In OS#3 (Mechanical + 100% Economizer Cooling), the following Fault Conditions shall be evaluated:
   - a) FC#1: Duct static pressure is too low with fan at full speed
   - b) FC#2: MAT too low; should be between RAT and OAT
   - c) FC#3: MAT too high; should be between RAT and OAT
   - d) FC#4: Too many changes in Operating State
   - e) FC#10: MAT and OAT should be approximately equal
   - f) FC#11: OAT too low for 100% OA
   - g) FC#12: SAT too high; should be less than MAT
4) In OS#4 (Mechanical Cooling, Min OA), the following Fault Conditions shall be evaluated:

a) FC#1: Duct static pressure is too low with fan at full speed
b) FC#2: MAT too low; should be between RAT and OAT
c) FC#3: MAT too high; should be between RAT and OAT
d) FC#4: Too many changes in Operating State
e) FC#6: OA fraction is too low or too high; should equal %OAMIN
f) FC#12: SAT too high; should be less than MAT
g) FC#13: SAT too high in full cooling
h) FC#15: Temperature rise across inactive heating coil

5) In OS#5 (Other), the following Fault Conditions shall be evaluated:

a) FC#1: Duct static pressure is too low with fan at full speed
b) FC#2: MAT too low; should be between RAT and OAT
c) FC#3: MAT too high; should be between RAT and OAT
d) FC#4: Too many changes in Operating State

b. For each air handler, the operator shall be able to suppress the alarm for any Fault Condition.

c. Evaluation of Fault Conditions shall be suspended under the following conditions:
   1) When AHU is not operating.
   2) For a period of ModeDelay minutes following a change in Mode (e.g. from Warm-up to Occupied) of any Zone Group served by the AHU.

d. Fault Conditions that are not applicable to the current Operating State shall not be evaluated.

e. A Fault Condition that evaluates as true must do so continuously for AlarmDelay minutes before it is reported to the operator.
   1) Test Mode shall temporarily set ModeDelay and AlarmDelay to 0 minutes for a period of TestModeDelay minutes to allow instant testing of the AFDD system, while ensuring that normal fault detection occurs after testing is complete.

e. When a Fault Condition is reported to the operator, it shall be a Level 3 alarm and shall include the description of the fault and the list of possible diagnoses from the table in Paragraph 3.3K.9.f.

11. Testing/Commissioning Overrides: Provide software switches that interlock to a chilled water and hot water plant level to

   a. If there is a hot water coil, force hot water valve full open
   b. If there is a hot water coil, force hot water valve full closed
   c. Force chilled water valve full open
   d. Force chilled water valve full closed

12. Plant Requests

   a. Send Heating Plant Requests as follows:
      1) If the HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 10%
      2) Else if the HW valve position is less than 95%, send 0 Requests.

L. Lab Exhaust Fans

1. Three manifolded fans exhaust the laboratory and maintain pressurization in the labs.
2. Exhaust Fan Start/Stop
1) Each set of general exhaust fans will be enabled 24/7 to maintain minimum air change rate in the labs.

2) Each fan has a corresponding set of isolation dampers. The isolation air dampers shall be fully open when the exhaust fan is proven on (see below for startup fan/damper startup sequence). Otherwise they shall be closed.

3) When starting a fan: Command the new fan to minimum speed and command the isolation damper to open. After damper feedback indicates that dampers are fully open, fan shall receive the same speed command as other operating fans.
   a) If proof of fan operation is not obtained within 30 seconds after start command, or if isolation damper feedback does not indicate fully open dampers after 120 seconds, disable fan, close associated dampers and set a Level 3 alarm.

4) When stopping a fan: Command the fan being stopped to minimum speed and command the isolation dampers to close. After 60 seconds, command the fan to stop.

3. Exhaust Fan Speed Control & Staging
   1) Fan speed is controlled to maintain duct static pressure and/or exhaust manifold static pressure at setpoint when the fan is proven on. As multiple static pressure sensors are associated with a single set of fans, modulate fan speed to maintain all measured static pressure sensors at or above setpoint.
   2) Exhaust fans serving a common plenum shall be controlled together and receive the same speed signal.
   3) If fans are operating at minimum speed determined by stack velocity criteria and all duct static pressure sensors are more than 10% above their duct static pressure setpoint for five minutes, fans shall stage down.
      a) Stop one fan per stage-down event.
   4) If a fan is operating at greater than 90% speed for five minutes, fans shall stage up.
      a) Start second fan per stage-up event.

4. Bypass Damper
   a. The bypass damper shall be modulated to maintain minimum exhaust velocity in the stacks.
   b. If the exhaust fans are meeting static pressure setpoints, but the velocity is too low, the bypass damper shall be opened until minimum velocity in the stack(s) is met.

5. Minimum Velocity in Stack
   a. The fans and bypass damper shall maintain the nominal velocity in the exhaust stack(s). Refer to 3.1L.1 for minimum stack exhaust velocity.
   b. If door contacts indicate that someone has either entered or left the Observation Deck, the minimum exhaust velocity shall be reset for the next 12 hours to the value defined by 3.1L.2.

6. Exhaust Airflow Measurement
   1) Sum-of-Zones: Totalize current airflow rate from Exhaust boxes to a software point \( EV_{\text{ps}} \) and display this sum-of-zones airflow near the intake duct on general exhaust graphic.
   2) Total Exhaust Airflow: Display AFMS measured airflow rate (from fan-inlet AFMS) adjacent to the sum-of-zone exhaust airflow rate.
7. Alarms
   a. Maintenance interval alarm when fan has operated for more than 1,500 hours: Level 4. Reset interval counter when alarm is acknowledged.
   b. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.
      1) Commanded on, status off: Level 2
      2) Commanded off, status on: Level 4
   c. Fan alarm is indicated when exhaust air setpoint cannot be maintained at any sensor for more than 5 minutes: Level 4.

M. Lab Exhaust Heat Recovery
   1. Lab heat recovery is used to pre-heat or pre-cool air in the main air handler by rejecting or absorbing heat from the lab exhaust air.
   2. Exhaust heat recovery system is enabled when there is available heat or “coolth” to pull from the exhaust air stream as follows:
      a. Cooling
         1) If the outside air temperature is 3°F or more above the supply air temperature setpoint and the outside air temperature is 3°F or higher than the exhaust air temperature, the loop shall operate in cooling mode.
      b. Heating
         1) When the outside air temperature is 3°F or more below the supply air temperature setpoint and the outside air temperature is 3°F or more below the exhaust air temperature, the loop shall operate in heating mode.
   3. When exhaust heat recovery is enabled:
      a. Close HHW isolation valves, wait until feedback indicates valves are closed, then open heat recovery coil isolation valves.
      b. Open HHW Coil Control valve(s) 100%. Valve(s) shall remain fully open the entire time.
      c. Open all heat recovery isolation valves associated with a running exhaust fan. If a lab fan stages off, close its associated heat recovery isolation valve. If a new lab exhaust fan stages on, open that associated isolation valve.
      d. Heat recovery loop pump speed is modulated by the supply air temperature control loop. Heat recovery pumps shall be staged lead-standby for equal wear rotation. If one pump fails, the other pump shall continue to operate.
   4. When an exhaust heat recovery system is disabled:
      a. Close heat recovery coil isolation valves.
      b. Close all lab exhaust heat recovery isolation valves.
      c. Heat recovery loop pump is locked out.
   5. Alarms
      a. Generate a Level 5 maintenance alarm when either pump has operated for more than 3000 hours. Reset interval counter when alarm is acknowledged.
      b. Pump alarm is indicated by the status input being different from the output command after a period of 15 seconds after a change in output status.
         1) Commanded on, status off: Level 2
         2) Commanded off, status on: Level 4
N. BAS Fire Alarm Mode

1. In the event the BAS receives a signal from the fire alarm panel that the building is in fire alarm mode, the following sequence shall be initiated to ensure safe conditions for evacuating the building. See 3.2F.1 for TAB procedure to determine setpoints.

2. Immediately upon receipt of fire alarm signal:
   a. Air handler supply and return fans shall be commanded off.
   b. Lab supply air valves shall close.
   c. Lab general exhaust air valves shall close.
   d. Lab fume hood exhaust air valves shall fail in place.
   e. The bypass damper shall be commanded to position BD_P1.
   f. Lab exhaust fans shall be commanded to a minimum speed determined in conjunction with TAB to maintain duct static pressure setpoint DSP_FA.

3. Over time interval \( T \):
   a. Gradually close bypass damper from initial position to BD_P1 to BD_P2. The intent is that the damper closes over the same time interval as the fan slowing down.

O. Exhaust Fan, Temperature Controlled

1. See Generic Thermal Control Zones (Paragraph 3.3B) for setpoints, loops, control modes, alarms, etc.

2. See Paragraph 3.2D.1.a for exhaust fan maximum speed setpoint MaxSpeed.

3. Exhaust fan shall be continuously enabled (i.e. available to run, not necessarily running).

4. Space shall be maintained at the cooling setpoint by a P-only loop which resets exhaust fan speed from minimum speed to MaxSpeed. Fan shall be stopped if zone temperature is below cooling setpoint.

5. Alarms
   a. Generate a Level 5 maintenance alarm when fan has operated for more than 3000 hours. Reset interval counter when alarm is acknowledged.
   b. Fan alarm is indicated by the status input being different from the output command after a period of 15 seconds after a change in output status.
      1) Commanded on, status off: Level 2
      2) Commanded off, status on: Level 4
   c. High space temperature alarm
      1) 5°F above setpoint for 15 minutes: Level 3
      2) 10°F above setpoint for 5 minutes: Level 2

P. Domestic Hot Water Plant

1. Heat pump water heater shall be controlled by manufacturer internal controls to maintain domestic hot water tanks at setpoint.

2. Heat pump water heater shall be connected to BAS for monitoring.

Q. Resource Meters

1. Connect BAS to outputs for each meter (electric, gas, and/or water) shown on Contract Drawing control schematics.
   a. For pulse output meters, determine and verify conversion between pulse count and resource consumption. Document the value and source of the conversion factor as a comment in code.
For meters using analog outputs, determine and verify conversion between analog signal and rate of resource consumption. Document the value and source of the conversion factor as a comment in code.

For networked meters, map meter points to BAS using BACnet point autodiscovery.

Networked meters which are not native BACnet devices or require the use of a gateway or protocol translator are not acceptable. See “BACnet Gateways and Network Devices” in Part 2 of Section 25 50 00.

After installation, verify that information reported by DDC System matches actual consumption. Submit verification with Functional Test Report as required by Section 25 50 00. **DDC Contractor is responsible for ensuring accuracy of meter information reported by DDC System.**

Report cumulative electricity and water use at the operator’s front end for:

a. Current day
b. Previous day
c. Current month to date
d. Previous month to date
e. Total since last reset

Trend meter outputs in accordance with the requirements of this Section and Section 25 50 00.

END OF SECTION
SECTION 260413 - COMMON SUBMITTAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:
   1. Action Codes Permitting Use:
      a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
      b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
      c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

   1. Action Code for Information Only:
      a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.

   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.

   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition

   1. Each submittal consists of items from only ONE Specifications section.
2. **Complete Submittal:** If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. **Partial Submittals:** If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. **Submittal Numbering**

1. Number submittals as described below to assist tracking.

2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 **SUBMITTAL REVIEW SHEET REQUIREMENTS**

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 260513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes cables and related cable splices, terminations, and accessories for medium-voltage (2001 to 35,000 V) electrical distribution systems.

1.3 DEFINITIONS

A. Jacket: A continuous nonmetallic outer covering for conductors or cables.


C. Sheath: A continuous metallic covering for conductors or cables.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

B. Samples: 16-inch lengths for each type of cable specified.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Indicate location of each cable, splice, and termination.

B. Qualification Data: For Installer.

C. Material Certificates: For each type of cable and accessory.

D. Design Data: Cable pulling calculations, including conduit size and fill percentage, pulling tensions, cable sidewall pressure, jam probability, voltage drop, and ground wire sizing for each cable.

E. Source quality-control reports.

F. Field quality-control reports.
1.6 QUALITY ASSURANCE
   A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.
   B. Testing Agency Qualifications: Member Company of NETA or an NRTL.
      1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 FIELD CONDITIONS
   A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
      1. Notify Construction Manager no fewer than five days in advance of proposed interruption of electric service.
      2. Do not proceed with interruption of electric service without Owner's written permission.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   B. Comply with IEEE C2 and NFPA 70.
   C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 CABLES
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Aetna Insulated Wire, Inc.
      2. Kerite Co. (The).
      3. Okonite Company (The).
   B. Cable Type: Type MV 105.
   C. Conductor Insulation: Ethylene-propylene rubber.
      1. Voltage Rating: 15 kV.
      2. Insulation Thickness: 133 percent insulation level.
   D. Conductor: Copper.
   E. Comply with UL 1072, AEIC CS8, ICEA S-93-639/NEMA WC 74, and ICEA S-97-682.
   F. Conductor Stranding: Compact round, concentric lay, Class B.
G. Shielding: Copper tape, helically applied over semiconducting insulation shield. Minimum of 25% overlap.

H. Cable Jacket: Sunlight-resistant PVC.

2.3 CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M.

B. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.

2.4 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M.
   3. Raychem; TE Connectivity.

C. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

D. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.
   1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
   2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
   3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders and carrying case.
2.5 MEDIUM-VOLTAGE TAPES

A. Description: Electrical grade, insulating tape rated for medium voltage application.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M.
   3. Raychem; TE Connectivity.

C. Ethylene/propylene rubber-based, 30-mil splicing tape, rated for 130 deg C operation. Minimum 3/4 inch wide.

D. Silicone rubber-based, 12-mil self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inches (38 mm) wide.

2.6 ARC-PROOFING MATERIALS

A. Description: Fire retardant, providing arc flash protection.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M.
   3. Raychem; TE Connectivity.

C. Tape for First Course on Metal Objects: 10-mil-thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

D. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch thick, and compatible with cable jacket.

E. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch wide.

2.7 FAULT INDICATORS

A. Indicators: Manually reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.
2.8 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 before shipping.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inches on the pull rope.
   1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
   2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.

C. Pull Conductors: Do not exceed manufacturer’s recommended maximum pulling tensions and sidewall pressure values.
   1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
   2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
   3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
   4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.

D. Support cables according to Section 26-05-29 "Hangers and Supports for Electrical Systems."

E. Install "buried-cable" warning tape 12 inches above cables.

F. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.

G. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.

H. Install cable splices at pull points and elsewhere as indicated; use standard kits.

I. Install separable insulated-connector components as follows:
   1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
3. Standoff Insulator: At each terminal junction, with one on each terminal.

J. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:
1. Clean cable sheath.
2. Wrap metallic cable components with 10-mil pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with two layers of 1-inch-wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.

K. Seal around cables passing through fire-rated elements according to Section 07 84 13 "Penetration Firestopping."

L. Install fault indicators on each phase where indicated.

M. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

N. Identify cables according to Section 26 05 53 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
3. Perform direct-current High Potential test of each new conductor according to NETA ATS, Ch. 7.3.3. Do not exceed cable manufacturer's recommended maximum test voltage.
4. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
5. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.

C. Medium-voltage cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION
 SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Copper building wire rated 600 V or less.
   2. Metal-clad cable, Type MC, rated 600 V or less.
   3. Armored cable, Type AC, rated 600 V or less.
   4. Tray cable, Type TC, rated 600 V or less.
   5. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:
   1. Section 26 05 13 "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 601 to 35,000 V.
   2. Section 27 13 13 "Communications Copper Backbone Cabling" for twisted pair cabling used for data circuits.
   3. Section 27 15 13 "Communications Copper Horizontal Cabling" for twisted pair cabling used for data circuits.

1.3 DEFINITIONS

A. RoHS: Restriction of Hazardous Substances.

B. VFC: Variable-frequency controller.

1.4 ACTION SUBMITTALS

A. Product Schedule: Indicate type, use, location, and termination locations.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member Company of NETA.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Alpha Wire Company.
   2. American Bare Conductor.
   3. Belden Inc.
   4. Cerro Wire LLC.
   5. Encore Wire Corporation.
   6. General Cable Technologies Corporation.
   7. Okonite Company (The).
   8. Service Wire Co.
   10. WESCO.

C. Standards:
   1. Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and use.
   2. RoHS compliant.
   3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

E. Conductor Insulation:
   1. Type THHN and Type THWN-2: Comply with UL 83.
   2. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
   3. Type XHHW-2: Comply with UL 44.

2.2 ARMORED CABLE, TYPE AC

A. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in an overall metallic sheath.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Alpha Wire Company.
   2. American Bare Conductor.
   3. Belden Inc.
   4. Cerro Wire LLC.
   5. Encore Wire Corporation.
   6. General Cable Technologies Corporation.
   7. Okonite Company (The).
   8. Service Wire Co.
   10. WESCO.
C. Standards:
1. Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Circuits:

E. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

F. Ground Conductor: Insulated.

G. Conductor Insulation: Type THHN/THWN-2. Comply with UL 83. Temperature rating of conductors’ size #8 and lower 70 Degree C and size #6 and larger 90 Degree C.

H. Armor: Steel, interlocked.

2.3 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. 3M Electrical Products.
2. AFC Cable Systems; a part of Atkore International.
5. Ideal Industries, Inc.
6. ILSCO.
7. NSI Industries LLC.
8. O-Z/Gedney; a brand of Emerson Industrial Automation.
10. TE Connectivity Ltd.
11. Thomas & Betts Corporation; A Member of the ABB Group.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
1. Material: Copper.
2. Type: Two hole with long barrels.
3. Termination: Crimp.
PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Feeders: Copper for feeders smaller than No. 4 AWG; copper for feeders No. 4 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Branch Circuits: Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.

D. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.


3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

J. VFC Output Circuits: Type XHHW-2 in metal conduit Type TC-ER cable with braided shield.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
B. Complete raceway installation between conductor and cable termination points according to Section 26 05 33 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 26 05 29 "Hangers and Supports for Electrical Systems."

G. Complete cable tray systems installation according to Section 26 05 36 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unsheathed conductors.
   1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 26 05 53 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 07 84 13 "Penetration Firestopping."
3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.
   1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
   2. Perform each of the following visual and electrical tests:
      a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
      b. Test bolted connections for high resistance using one of the following:
         1) A low-resistance ohmmeter.
         2) Calibrated torque wrench.
         3) Thermographic survey.
      c. Inspect compression-applied connectors for correct cable match and indentation.
      d. Inspect for correct identification.
      e. Inspect cable jacket and condition.
      f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
      g. Continuity test on each conductor and cable.
      h. Uniform resistance of parallel conductors.

   3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
      a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
      b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

   4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

C. Cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports to record the following:
   1. Procedures used.
   2. Results that comply with requirements.
   3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION
SECTION 260526 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment, plus the following special applications:
   1. Underground distribution grounding.
   2. Ground bonding common with lightning protection system.
   3. Foundation steel electrodes.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
   1. Test wells.
   2. Ground rods.
   3. Ground rings.
   4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 01785 "Operation and Maintenance Data," include the following:
      a. Plans showing as-built, dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
         1) Test wells.
         2) Ground rods.
         3) Ground rings.
         4) Grounding arrangements and connections for separately derived systems.
      b. Instructions for periodic testing and inspection of grounding features at test wells and grounding connections for separately derived systems based on NETA MTS and NFPA 70B.
         1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
         2) Include recommended testing intervals.
PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Burndy; Part of Hubbell Electrical Systems.
   2. ERICO International Corporation.
   3. ILSCO.
   4. O-Z/Gedney; a brand of Emerson Industrial Automation.
   5. SIEMENS Industry, Inc.; Energy Management Division.
   6. Thomas & Betts Corporation; A Member of the ABB Group.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
   4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
   5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
   6. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

G. Conduit Hubs: Mechanical type, terminal with threaded hub.

H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

J. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

K. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

L. Straps: Solid copper, cast-bronze clamp. Rated for 600 A.

M. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal two-piece clamp.

N. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

O. Water Pipe Clamps:
   1. Mechanical type, two pieces with zinc-plated bolts.
      b. Listed for direct burial.
   2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.

B. Ground Plates: 1/4 inch thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install barecopper conductor, No. 2/0 AWG minimum.
   1. Bury at least 24 inches below grade.
   2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Bolted connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.
3.5   EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

G. Metallic Fences: Comply with requirements of IEEE C2.
   1. Grounding Conductor: Bare copper, not less than No. 8 AWG.
   2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
   3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.6   INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
   1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
   2. Use exothermic welds for all below-grade connections.
   3. For grounding electrode system, install at least three rods spaced at least two -rod lengths from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.
   1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each indicated item, extending around the perimeter of area or item indicated.
   1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
   2. Bury ground ring not less than 24 inches from building's foundation.

J. Concrete-Encased Grounding Electrode (UFER Ground): Fabricate according to CEC 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
   1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
   2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

K. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
   1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
   a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
   b. Perform tests by fall-of-potential method according to IEEE 81.
4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION
SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Steel slotted support systems.
   2. Aluminum slotted support systems.
   3. Nonmetallic slotted support systems.
   4. Conduit and cable support devices.
   5. Support for conductors in vertical conduit.
   6. Structural steel for fabricated supports and restraints.
   7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
   8. Fabricated metal equipment support assemblies.

B. Related Requirements:
   1. Section 26 05 48.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 ACTION SUBMITTALS

A. Hangers and supports are not deferred submittal nor a delegated design item. A complete design shall be provided on construction drawings.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Ductwork, piping, fittings, and supports.
   3. Structural members to which hangers and supports will be attached.
   4. Items penetrating finished ceiling, including the following:
      a. Luminaires.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
      f. Projectors.

B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Hangers and supports are not deferred submittal nor delegated design items. Refer to details on drawings for requirements.
   1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the supported equipment and systems will be fully operational after the seismic event."
   2. Component Importance Factor: 1.5.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Allied Tube & Conduit; a part of Atkore International.
      b. B-line, an Eaton business.
      c. Thomas & Betts Corporation; A Member of the ABB Group.
      d. Unistrut; Part of Atkore International.
   2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
   4. Channel Width: Selected for applicable load criteria.
   5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
   1. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1) Kwik Bolt TZ, by Hilti, Inc. per ICC-ES ESR-1917.
   2) Cooper B-Line Power-Stud + SD1 ICC-ES ESR-2818.

2. Concrete Inserts: Kwik HUS-EZ screw anchor and HUS-EZ1 rod hanger, by Hilti Inc. per ICC-ES ESR 3027.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 05 50 00 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
   1. NECA 1.
   2. NECA 101
   3. NECA 102.
   4. NECA 105.

B. Comply with requirements in Section 07 84 13 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in CEC 70. Minimum rod size shall be 1/4 inch in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 50 percent in future without exceeding specified design load limits.
   1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.
3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   1. To Wood: Fasten with lag screws or through bolts.
   2. To New Concrete: Bolt to concrete inserts.
   3. To Existing Concrete: Expansion anchor fasteners.
   4. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
   5. To Light Steel: Sheet metal screws.
   6. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 05 50 00 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 03 30 00 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:
   1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION
SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Metal conduits and fittings.
   2. Nonmetallic conduits and fittings.
   3. Metal wireways and auxiliary gutters.
   4. Surface raceways.
   5. Boxes, enclosures, and cabinets.
   6. Handholes and boxes for exterior underground cabling.

B. Related Requirements:
   1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.
   2. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
   3. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.

1.3 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

B. EMT: Electrical metallic tubing conduit.

C. PVC: Polyvinyl chloride conduit.

1.4 ACTION SUBMITTALS

A. Samples: For wireways and surface raceways and for each color and texture specified, 12 inches long.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
   1. Structural members in paths of conduit groups with common supports.
   2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
3. Where raceways are crossing exposed ceiling spaces visible to the building occupants and where indicated on plans.

B. Qualification Data: For professional engineer.

C. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. AFC Cable Systems; a part of Atkore International.
   b. Allied Tube & Conduit; a part of Atkore International.
   c. Cal conduit.
   d. Electri-Flex Company.
   e. FSR Inc.
   f. O-Z/Gedney; a brand of Emerson Industrial Automation.
   g. Thomas & Betts Corporation; A Member of the ABB Group.
   h. Western Tube and Conduit Corporation.
   i. Wheatland Tube Company.
2. Listing and Labeling: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with ANSI C80.1 and UL 6.
4. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
   a. Comply with NEMA RN 1.
   b. Coating Thickness: 0.040 inch, minimum.
5. EMT: Comply with ANSI C80.3 and UL 797.
6. FMC: Comply with UL 1; zinc-coated steel.
7. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. AFC Cable Systems; a part of Atkore International.
   b. Allied Tube & Conduit; a part of Atkore International.
   c. Anamet Electrical, Inc.
   d. FSR Inc.
   e. O-Z/Gedney; a brand of Emerson Industrial Automation.
   f. Thomas & Betts Corporation; A Member of the ABB Group.
   g. Western Tube and Conduit Corporation.
   h. Wheatland Tube Company.
2. Comply with NEMA FB 1 and UL 514B.
3. Listing and Labeling: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.
5. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and CEC 70.
6. Fittings for EMT:
a. Material: Steel.
   b. Type: Setscrew or compression.

7. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

8. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

C. Joint Compound for GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. AFC Cable Systems; a part of Atkore International.
      b. Arnco Corporation.
      c. CANTEX INC.
      d. Electri-Flex Company.
      e. RACO; Hubbell.
      f. Thomas & Betts Corporation; A Member of the ABB Group.
   2. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.
   3. ENT: Comply with NEMA TC 13 and UL 1653.
   4. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
   5. LFNC: Comply with UL 1660.
   6. Rigid HDPE: Comply with UL 651A.
   7. Continuous HDPE: Comply with UL 651A.
   8. Coilable HDPE: Preassembled with conductors or cables and complying with ASTM D 3485.

B. Nonmetallic Fittings:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. AFC Cable Systems; a part of Atkore International.
      b. Arnco Corporation.
      c. CANTEX INC.
      d. FRE Composites.
      e. RACO; Hubbell.
      f. Thomas & Betts Corporation; A Member of the ABB Group.

   2. Fittings, General: Listed and labeled for type of conduit, location, and use.
   3. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
      a. Fittings for LFNC: Comply with UL 514B.
   4. Solvents and Adhesives: As recommended by conduit manufacturer.
2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
2. Hoffman; a brand of Pentair Equipment Protection.
3. MonoSystems, Inc.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 3R unless otherwise indicated, and sized according to CEC 70.
1. Metal wireways installed outdoors shall be listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Aluminum Raceways: Alloy 6063-T5 extruded aluminum, minimum thickness 0.050 inches. Satin, No. 204 clear anodized, 0.004-inch-thick, Class R1 Mil-Spec finish. Device cover plates suitable to mount commercially available duplex devices, single 1.40 inch and 1.59-inch diameter receptacles, GFCI, surge receptacles and other rectangular faced devices, and voice and data jacks. Devices shall be mounted to cover plates held in place by extruded protrusions. Cover plates shall be removable using standard screwdriver without marring the finish.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Thomas & Betts Corporation.
   c. Wiremold Company (The); Electrical Sales Division

2.5 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Adalet.
3. EGS/Appleton Electric.
5. FSR Inc.
6. Hoffman; a brand of Pentair Equipment Protection.
8. Hubbell Incorporated; Wiring Device-Kellems.
10. MonoSystems, Inc.
11. Oldcastle Enclosure Solutions.
13. RACO; Hubbell.
14. Spring City Electrical Manufacturing Company.
15. Thomas & Betts Corporation; A Member of the ABB Group.
16. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal pressed Outlet and Device Boxes with not welded edges: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:
   1. Type FL-500P/600P Floor box and cover, Multi-service flush mounted floor box with UL scrub water approved.
      a. Material: Cast metal.
      b. Type: Fully adjustable.
      c. Shape: Rectangular.
      d. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.
   2. Type FL-500P/600P Floor box and cover, Recessed multi-service flush mounted box with hinged cover and cord access flap with UL scrub water approved label.
      a. Material: Cast metal.
      b. Type: Fully adjustable.
      c. Shape: Rectangular.
      d. Size: 10”x12”x6” Deep
      e. Knock-out fittings: (8) ¾”, (12) concentric 1”/1¼”/1½”
      f. Cover: Cover with brass carpet flange, life off door and UL scube water rated for tile and carpet installation, coordinate brass flange height with architect Cover with aluminum carpet flange, life off door and UL scube water rated for tile and carpet installation, coordinate aluminum flange height with architect. Solid cover with cable exit, no trim, color as selected by Architect

G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

J. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

K. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
L. Gangable boxes are prohibited.

M. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 and Type 3R with continuous-hinge cover with flush latch unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
   2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

N. Cabinets:
   1. NEMA 250, Type 1 and Type 3R galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
   2. Hinged door in front cover with flush latch and concealed hinge.
   3. Key latch to match panelboards.
   4. Metal barriers to separate wiring of different systems and voltage.
   5. Accessory feet where required for freestanding equipment.

O. Monuments:
   1. WaterSaver pedestal electrical box with ¾” hub, single-gang catalog number E300SAA, two-gang catalog number E400SA and E500SA, and four-gang catalog number E600SA;
      a. Hubbell.
      b. LeGrand.
      c. Or Approved Equal.
      d. If alternate product is submitted, all material and functional requirements of the specified product must demonstrated and documented to be equal.
   2. Pedestals shall have single-piece aluminum base and housing, integral raised threaded hub, and shall contain devices as shown on drawings. Housing shall be brushed.

2.6 HANDBHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:
   1. Boxes and handholes for use in underground systems shall be designed and identified as defined in CEC 70, for intended location and application.
   2. Boxes installed in wet areas shall be listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Armorcast Products Company.
      b. NewBasis.
      c. Oldcastle Enclosure Solutions.
      d. Oldcastle Precast, Inc.
      e. Quazite: Hubbell Power Systems, Inc.
   2. Standard: Comply with SCTE 77.
   3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
   4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
   5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   6. Cover Legend: Molded lettering, "ELECTRIC."
   7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
   1. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
   2. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed Conduit: GRC.
   2. Concealed Conduit, Aboveground: GRC IMC EMT.
   3. Underground Branch Conduit: RNC, Type EPC-40-PVC Type and Rigid HDPE, direct buried.
   4. Underground Feeder Conduit: Type EPC-40-PVC and Type Rigid HDPE concrete encased.
   5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
   6. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: EMT.
   2. Exposed, Not Subject to Severe Physical Damage: EMT.
   3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
      a. Loading dock.
      b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
      c. Mechanical rooms.
   4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
   5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
   6. Damp or Wet Locations: GRS.
   7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Interior Raceway Size: 3/4-inch trade size.

D. Minimum Exterior Raceway Size: 1-1/4" inch

E. Raceway Fittings: Compatible with raceways and suitable for use and location.
   1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.

3. EMT: Use setscrew or compression, steel fittings. Comply with NEMA FB 2.10.

4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

F. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

G. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

H. Install surface raceways only where indicated on Drawings.

I. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 RACEWAY SEPARATION OF SYSTEM WIRING

A. Provide minimum separations between power and wiring and signal system wiring as indicated in table below. Where minimum separation can not be maintained due to existing conditions obtain written permission for closer spacing.

<table>
<thead>
<tr>
<th>Power Raceways (70 Volts or More)</th>
<th>Transformers, and Motor Starters</th>
<th>Motors with Dimming Circuits</th>
<th>Power Raceways</th>
<th>Lighting Fixtures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telephone</td>
<td>5”</td>
<td>12”</td>
<td>24”</td>
<td>12”</td>
</tr>
<tr>
<td>DATA</td>
<td>5”</td>
<td>12”</td>
<td>24”</td>
<td>12”</td>
</tr>
<tr>
<td>Paging / Sound</td>
<td>5”</td>
<td>12”</td>
<td>24”</td>
<td>5”</td>
</tr>
<tr>
<td>Security</td>
<td>5”</td>
<td>12”</td>
<td>24”</td>
<td>5”</td>
</tr>
<tr>
<td>CCTV</td>
<td>5”</td>
<td>12”</td>
<td>24”</td>
<td>5”</td>
</tr>
<tr>
<td>Monitoring and Control</td>
<td>5”</td>
<td>12”</td>
<td>24”</td>
<td>5”</td>
</tr>
<tr>
<td>Fire Alarm</td>
<td>5”</td>
<td>12”</td>
<td>24”</td>
<td>5”</td>
</tr>
<tr>
<td>Cable Tray</td>
<td>12”</td>
<td>24”</td>
<td>24”</td>
<td>12”</td>
</tr>
</tbody>
</table>

3.3 RACEWAY APPLICATIONS

<table>
<thead>
<tr>
<th>ENVIRONMENT</th>
<th>RACEWAYS</th>
<th>BOXES, ENCLOSES, AND CABINETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry locations, concealed</td>
<td>RMC, EMT, FMC, LFMC, WW</td>
<td>SM, FS/FD; NEMA 1</td>
</tr>
<tr>
<td>Dry locations, exposed, subject to</td>
<td>RMC</td>
<td>SM, FS/FD; NEMA 1</td>
</tr>
<tr>
<td>damage*</td>
<td>RMC, EMT, FMC, LFMC, WW</td>
<td>SM, FS/FD; NEMA 1</td>
</tr>
<tr>
<td>Wet locations, subject to damage</td>
<td>RMC</td>
<td>FS/FD; NEMA 4, 4X</td>
</tr>
<tr>
<td>damage*</td>
<td>RMC</td>
<td></td>
</tr>
</tbody>
</table>

Contra Costa Community College District
Contra Costa College
C-4016 New Science Building – DSA Backcheck
<table>
<thead>
<tr>
<th>ENVIRONMENT</th>
<th>RACEWAYS</th>
<th>BOXES, ENCLOSURES, AND CABINETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet locations, not subject to damage</td>
<td>RMC3, EMT3, LFMC, WW7</td>
<td>FS/FD; NEMA 4, 4X</td>
</tr>
<tr>
<td>Outdoor locations, exposed to rain, sleet, windblown dust, and external icing</td>
<td>RMC3, WW7, LFMC12</td>
<td>FS/FD; NEMA 3, 3R, 3S</td>
</tr>
<tr>
<td>Outdoor locations, underground</td>
<td>RMC, PVC, LFMC</td>
<td>SCTE 77</td>
</tr>
<tr>
<td>Outdoor locations, submerged</td>
<td>RMC3, PVC</td>
<td>NEMA 6, 6P</td>
</tr>
<tr>
<td>Outdoor locations, embedded in concrete</td>
<td>RMC, EMT4, PVC</td>
<td>FS/FD</td>
</tr>
<tr>
<td>Under concrete slab</td>
<td>RMC, PVC</td>
<td>N/A</td>
</tr>
<tr>
<td>Underground, direct burial</td>
<td>RMC3, PVC, LFMC</td>
<td>SUTE 77</td>
</tr>
<tr>
<td>Embedded burial</td>
<td>RMC, PVC</td>
<td>N/A</td>
</tr>
<tr>
<td>Industrial location, general</td>
<td>RMC EMT, FMC, LFMC, WW</td>
<td>FS/FD, SM; NEMA 12, 12K</td>
</tr>
<tr>
<td>Industrial location, subject to corrosion</td>
<td>RMC3, LFMC</td>
<td>NEMA 4X, 11</td>
</tr>
<tr>
<td>Industrial location, subject to oil and vapors</td>
<td>RMC, LFMC</td>
<td>FS/FD; NEMA 13</td>
</tr>
<tr>
<td>Hazardous Class I, Division 1</td>
<td>RMC, IMC</td>
<td>NEMA 7, 8</td>
</tr>
<tr>
<td>Hazardous Class I, Division 2</td>
<td>RMC, LFMC, FMC11, WW5</td>
<td>FS/FD; NEMA 1, 7, 8, 12</td>
</tr>
<tr>
<td>Hazardous Class II, Division 1</td>
<td>RMC, LFMC</td>
<td>NEMA 9</td>
</tr>
<tr>
<td>Hazardous Class II, Division 2a</td>
<td>RMC, LFMC, WW6</td>
<td>FS/FD; NEMA 1, 9, 12</td>
</tr>
<tr>
<td>Hazardous Class III</td>
<td>RMC, LFMC, WW6</td>
<td>FS/FD; NEMA 12</td>
</tr>
</tbody>
</table>

Legend: EMT Electrical metallic tubing 1. Building finishes must provide a barrier with a 15-minute fire rating. ENT Electrical nonmetallic conduit 2. For buildings not more than three stories above grade. FS/FD Cast-metal conduit 3. Corrosion protection is required. HDPE High-density polyethylene conduit 4. With fittings for purpose. LFMC Liquidtight flexible metal conduit 5. Enclosed gasketed. LFNC Liquidtight flexible nonmetallic conduit 6. Dust-tight wireway only. N/A Not applicable 8. Nonincendive and intrinsically safe wiring are allowed in any classification. NEMA Refers to NEMA 250, type wiring method permitted for unclassified locations. NM Nonmetallic box 9. Aluminum materials are permitted only with approved supplementary corrosion protection. PVC Rigid polyvinyl chloride conduit 10. Schedule 80. RMC Rigid metal conduit 11. Only as specifically permitted under the environmental condition. RTRC Reinforced thermosetting resin conduit 12. Subject to temperature limitations where exposed to sunlight. SM Sheet-metal box 7. Raintight wireway only. WW Wireway 6. Dust-tight wireway only. *“Subject to damage” denotes environments where exposed raceways may be impacted by traffic, by cleaning or maintenance operations, or by similar influences.
3.4 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with CEC 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Complete raceway installation before starting conductor installation.

G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

H. Install, for 70 volt and above, no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

I. Install, for below 70 volt raceways, no more than the equivalent of two 90-degree bends in any conduit run. Support within 12 inches of changes in direction.

J. Make bends in raceway using large-radius preformed ells. Field bending shall be according to CEC 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

K. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

L. Support conduit within 12 inches of enclosures to which attached.

M. Stub-ups to Above Recessed Ceilings:
   1. Use EMT or RMC for raceways.
   2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

P. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
Q. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

R. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

S. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

T. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

U. Surface Raceways:
1. Install surface raceway with a minimum 2-inch radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

V. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to CEC 70.

W. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by CEC 70.

X. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

Y. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
   a. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
   b. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
   c. Attics: 135 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install...
fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.

4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.

5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

Z. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage.

AA. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

BB. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

CC. Locate boxes so that cover or plate will not span different building finishes.

DD. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

EE. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

FF. Set metal floor boxes level and flush with finished floor surface.

GG. Set non-metallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.5 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Branch Circuit Conduit (600 V and below):
1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312333 "Utility Trenching and Backfilling" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 312333 "Utility Trenching and Backfilling."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312333 “Utility Trenching and Backfilling.”
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
   a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
   b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a
3.6 INSTALLATION OF UNDERGROUND HANDOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.8 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.9 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION
NOT USED
SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

   A. Section Includes:
      1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
      2. Rigid nonmetallic duct.
      3. Flexible nonmetallic duct.
      4. Duct accessories.
      5. Precast concrete handholes.
      6. Polymer concrete handholes and boxes with polymer concrete cover.
      7. Fiberglass handholes and boxes with polymer concrete cover.
      8. Fiberglass handholes and boxes.
      9. High-density plastic boxes.

1.3 DEFINITIONS

   A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.

   B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

   C. Duct Bank:
      1. Two or more ducts installed in parallel, with or without additional casing materials.
      2. Multiple duct banks.

   D. GRC: Galvanized rigid (steel) conduit.

   E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

   A. Sustainable Design Submittals:

1.5 INFORMATIONAL SUBMITTALS

   A. Coordination Drawings: For duct and duct bank. Show duct profiles and coordination with other utilities and underground structures.
1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer.

B. Field quality-control reports.

1.6 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:
1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

B. Ground Water: Assume ground-water level is 36 inches below ground surface unless a higher water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

A. GRC: Comply with ANSI C80.1 and UL 6.

B. Coated Steel Conduit: PVC-coated GRC.
1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

C. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. AFC Cable Systems; a part of Atkore International.
2. Allied Tube & Conduit; a part of Atkore International.
3. Anamet Electrical, Inc.
5. O-Z/Gedney; a brand of Emerson Industrial Automation.
6. Republic Conduit.

D. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

B. Underground Plastic Utilities Duct: Type EPEC-40 HDPE, complying with NEMA TC 7 and UL 651A.

C. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. ARNCO Corp.
2. CANTEX INC.
5. Electri-Flex Company.

D. Listed and labeled as defined in CEC 70, by a nationally recognized testing laboratory, and marked for intended location and application.

E. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 FLEXIBLE NONMETALLIC DUCTS

A. HDPE Duct: Type EPEC-80 HDPE, complying with NEMA TC 7 and UL 651A.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. ARNCO Corp.
      b. Carlon; a brand of Thomas & Betts Corporation.
      d. Opti-Com Manufacturing Network, Inc (OMNI).
      e. Premier Conduit.
   2. Listed and labeled as defined in CEC 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.4 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Allied Tube & Conduit; a part of Atkore International.
      b. CANTEX INC.
      c. Carlon; a brand of Thomas & Betts Corporation.
      d. IPEX USA LLC.
      e. PenCell Plastics.
      f. Underground Devices, Inc.
   B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 26 05 53 "Identification for Electrical Systems."

2.5 PRECAST CONCRETE HANHOLES AND BOXES

A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
   B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Christy Concrete Products.
2. Oldcastle Precast, Inc.
3. Utility Concrete Products, LLC.

C. Comply with ASTM C 858 for design and manufacturing processes.

D. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

E. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

F. Cover Legend: Molded lettering, as indicated for each service.

G. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.

H. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
   1. Extension shall provide increased depth of 12 inches.
   2. Slab: Same dimensions as bottom of enclosure and arranged to provide closure.

I. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

J. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
   1. Knockout panels shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
   2. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
   3. Knockout panels shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
   4. Knockout panels shall be 1-1/2 to 2 inches thick.

K. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.6 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Armorcast Products Company.
   2. NewBasis.
   3. Oldcastle Enclosure Solutions.

D. Color: Gray.

E. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.

F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

H. Cover Legend: Molded lettering, as indicated for each service.

I. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.

J. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.7 PRECAST MANHOLES

A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carder Concrete Products.
   2. Christy Concrete Products.
   3. Oldcastle Precast, Inc.
   4. Utility Concrete Products, LLC.
   5. Utility Vault Co.

C. Comply with ASTM C 858.

D. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

E. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
   1. Center window location.
   2. Knockout panels shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
   3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
   4. Knockout panel shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
   5. Knockout panels shall be 1-1/2 to 2 inches thick.

F. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
   1. Type and size shall match fittings to duct to be terminated.
2. Fittings shall align with elevations of approaching duct and be located near interior corners of manholes to facilitate racking of cable.

G. Ground Rod Sleeve: Provide a 3-inch PVC sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the duct entering the structure.

H. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.8 UTILITY STRUCTURE ACCESSORIES

A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Campbell Foundry Company.
   2. Christy Concrete Products.
   3. Oldcastle Precast, Inc.
   4. Utility Concrete Products, LLC.
   5. Utility Vault Co.

C. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
   1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 29 inches.
      a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
      b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
   2. Cover Legend: Cast in. Selected to suit system.
      a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
      b. Legend: "ELECTRIC-MV" for duct systems with medium-voltage cables.
   3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
      a. Seal joints watertight using preformed plastic or rubber complying with ASTM C 990. Install sealing material according to sealant manufacturers' written instructions.


E. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch-diameter eye, and 1-by-4-inch bolt.
   1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.

F. Pulling-in and Lifting Irons in Concrete Floors: 7/8-inch-diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
   1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.

G. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.
   1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.
H. Ground Rod Sleeve: 3-inch PVC sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.

I. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

J. Cable Rack Assembly: Steel, hot-dip galvanized, except insulators.
   1. Stanchions: T-section or channel with provisions to connect to other sections or channels to form a continuous unit; 1-1/2 inches in width by nominal 24 inches long; punched with 14 hook holes on 1-1/2-inch centers for cable-arm attachment.
   2. Arms: 1-1/2 inches wide, lengths ranging from 3 inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.

K. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

L. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin.

M. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two required.

2.9 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.

C. Clear and grub vegetation to be removed according to Section 311100 "Clearing and Grubbing," and protect vegetation to remain according to Section 31 10 01 "Plant Protection." Remove and stockpile topsoil for reapplication according to Section 31 23 00 "Excavation and Fill."
3.2 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Cables More Than 600 V: RNC, concrete-encased unless otherwise indicated.

B. Duct for Electrical Feeders 600 V and Less: EPEC-40 HDPE and Type EPC-40-PVC RNC, concrete-encased unless otherwise indicated.

C. Duct for Electrical Feeders 600 V and Less: Type EPEC-40 HDPE and Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.

D. Duct for Electrical Branch Circuits: Type EPEC-40 HDPE and Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.

E. Bored Underground Duct: Type EPEC-40 HDPE unless otherwise indicated.

F. Stub-ups: Concrete-encased GRC.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:
   1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-20 structural load rating.
   2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
   4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.
   5. Cover design load shall not exceed the design load of the handhole or box.

B. Manholes: Precast or cast-in-place concrete.
   1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
   2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Section 31 20 00 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restoration: Replace area immediately after backfilling is completed or after construction vehicle traffic in immediate area is complete.

C. Restore surface features at areas disturbed by excavation and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 32 92 00 "Turf and Grasses" and Section 32 93 00 "Plants."
E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 01 73 00 "Execution."

3.5 DUCT AND DUCT-BANK INSTALLATION

A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.

B. Install duct according to NEMA TCB 2.

C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.

D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 12.5 feet, both horizontally and vertically, at other locations unless otherwise indicated.

E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.

F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch duct, and vary proportionately for other duct sizes.
   1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell, without reducing duct slope and without forming a trap in the line.
   2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than 3/4 inch.

H. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches o.c. for 4-inch duct, and vary proportionately for other duct sizes.
   1. Begin change from regular spacing to terminator spacing 10 feet from the terminator, without reducing duct line slope and without forming a trap in the line.
   2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight-line duct with calculated expansion of more than 3/4 inch.

I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
J. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.


L. Concrete-Encased Ducts and Duct Bank:
   1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 31 20 00 “Earth Moving” for pipes less than 6 inches in nominal diameter.
   2. Width: Excavate trench 3 inches wider than duct on each side.
   3. Depth: Install so top of duct envelope is at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
   4. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
   5. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
   6. Minimum Space between Duct: 3 inches between edge of duct and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and communications ducts.
   7. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
   8. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.
      a. Couple RNC duct to GRC with adapters designed for this purpose and encase coupling with 3 inches of concrete.
      b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
         1) Stub-ups shall be minimum 4 inches above finished floor and minimum 3 inches from conduit side to edge of slab.
      c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.
         1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.
   9. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
   10. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
   11. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct to exterior envelope wall, 2 inches between duct of like services, and 4 inches between power and communications ducts.
   12. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
      a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings
installed according to manufacturer's written instructions or use other specific measures to prevent expansion-contraction damage.

b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.

13. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 03 30 00 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

M. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 31 20 00 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.

2. Width: Excavate trench 12 inches wider than duct on each side.

3. Depth: Install top of duct at least 36 inches below finished grade unless otherwise indicated.

4. Set elevation of bottom of duct bank below frost line.

5. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.

6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.

7. Install duct with a minimum of 3 inches between ducts for like services and 6 inches between power and communications duct.

8. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.

9. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.

a. Couple RNC duct to GRC with adapters designed for this purpose and encase coupling with 3 inches of concrete.

b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.

1) Stub-ups shall be minimum 4 inches above finished floor and minimum 3 inches from conduit side to edge of slab.

c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.

1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.

10. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfills to 4 inches over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 31 20 00 "Earth Moving" for installation of backfill materials.
a. Place minimum 6 inches of engineered fill above concrete encasement of duct.

N. Underground-Line Warning Tape: Bury conducting underground line specified in Section 26 05 53 "Identification for Electrical Systems" no less than 12 inches above all concrete-encased duct and duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Cast-in-Place Manhole Installation:
1. Finish interior surfaces with a smooth-troweled finish.
2. Knockouts for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches thick, arranged as indicated.
3. Comply with requirements in Section 03 30 00 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.

B. Precast Concrete Handhole and Manhole Installation:
1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevations:
1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
3. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
4. Where indicated, cast handhole cover frame integrally with handhole structure.

D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

E. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

F. Manhole Coatings:
1. Manhole interiors shall be coated with waterproofing coating. Waterproofing shall be of the cementitious crystalline type that chemically controls and permanently fixes non-soluble crystalline growth throughout the capillary voids of concrete. Coating shall be XYPEX Concentrate, Thoroseal or approved equal.

G. Waterproofing: Apply waterproofing to exterior surfaces of manholes after concrete has cured at least three days. Waterproofing materials and installation are specified in [Section 07 13 53 "Elastomeric Sheet Waterproofing."] [Section 07 13 54 "Thermoplastic Sheet Waterproofing."] After duct has been connected and grouted, and before backfilling,
waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

H. Dampproofing: Apply dampproofing to exterior surfaces of manholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 07 11 13 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

I. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

J. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

K. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

E. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

F. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screened to top of box cover frame. Bottom of ring shall rest on compacted earth.
   1. Concrete: 3000 psi, 28-day strength, complying with Section 03 30 00 "Cast-in-Place Concrete," with a troweled finish.
   2. Dimensions: 10 inches wide by 12 inches deep.
3.8 GROUNDING

A. Ground underground ducts and utility structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
   2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
   3. Test manhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump.
   1. Sweep floor, removing dirt and debris.
   2. Remove foreign material.

END OF SECTION
SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
   2. Sleeve-seal systems.
   5. Silicone sealants.

B. Related Requirements:
   1. Section 07 84 13 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Sustainable Design Submittals:

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:
   1. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:
   2. Minimum Metal Thickness:
      a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
      b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.
2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Advance Products & Systems, Inc.
      b. Holdrite (Engineered Sleeve Solutions).
      c. Pipeline Seal and Insulator, Inc.
   2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   3. Pressure Plates: Carbon steel.
   4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. HOLDRITE.

2.4 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
   1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
   1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
      a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 92 00 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.

4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.

5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
   1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
   2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION
SECTION 260548.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Restraint channel bracings.
   2. Restraint cables.
   4. Mechanical anchor bolts.
   5. Adhesive anchor bolts.

B. Related Requirements:
   1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
      b. Annotate to indicate application of each product submitted and compliance with requirements.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints. Electrical components include:
   1. Control and monitoring panels.
   2. Generators.
   3. Luminaires. Luminaires with pole.
   4. Panelboards.
   5. Substations.
   6. Transformers.

B. Qualification Data: For professional engineer and testing agency.

C. Field quality-control reports.
1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

D. Comply with CEC 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:
   1. Basic Wind Speed: 115 mph
   2. Building “Risk” Classification Category: III.
   3. Minimum 10 lb/sq. ft. multiplied by maximum area of component projected on vertical plane normal to wind direction and 45 degrees either side of normal.

B. Seismic-Restraint Loading:
   1. Site Class as Defined in the IBC: D.
   2. Building “Risk” Category as Defined in the IBC: III.
   3. Design Spectral Response Acceleration at Short Periods (0.2 Second). Refer to Sheet S0.02.
   4. Design Spectral Response Acceleration at 1.0-Second Period. Refer to Sheet S0.02.

2.2 RESTRAINT CHANNEL BRACINGS

A. Coordinate with system specified on Drawings: Mason West. Inc per OSHPD OPM-0043-13.

2.3 RESTRAINT CABLES

A. Coordinate with system specified on Drawings: Mason West. Inc per OSHPD OPM-0043-13.

2.4 SEISMIC-RESTRAINT ACCESSORIES

A. Coordinate with system specified on Drawings: Mason West. Inc per OSHPD OPM-0043-13.
2.3  RESTRAINT CABLES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Kinetics Noise Control, Inc.
   2. Vibration & Seismic Technologies, LLC.
   3. Vibration Mountings & Controls, Inc.

B. Restraint Cables: ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4  SEISMIC-RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. B-line, an Eaton business.
   2. Kinetics Noise Control, Inc.
   3. Mason Industries, Inc.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5  MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. B-line, an Eaton business.
   2. Hilti, Inc.
   4. Mason Industries, Inc.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.
C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   5. Set anchors to manufacturer's recommended torque using a torque wrench.
   6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections:
   1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
   4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
   5. Test to 90 percent of rated proof load of device.

C. Seismic controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.
3.6 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.


4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.

5. Test to 90 percent of rated proof load of device.

C. Seismic controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION

NOT USED
SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section Includes:
      1. Color and legend requirements for raceways, conductors, and warning labels and signs.
      2. Labels.
      4. Tapes and stencils.
      5. Tags.
      7. Cable ties.
      9. Fasteners for labels and signs.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
   A. Comply with NFPA 70.
   C. Comply with ANSI Z535.4 for safety signs and labels.
   D. Comply with NFPA 70E and Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.
   E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
   F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
      1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS
   A. Raceways and Cables Carrying Circuits at 600 V or Less:
      1. Black letters on an orange field.
      2. Legend: Indicate voltage and system or service type.
B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.
   1. Color shall be factory applied.
   2. Colors for 208/120-V Circuits:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
   3. Colors for 480/277-V Circuits:
      b. Phase B: Orange.
      c. Phase C: Yellow.
   6. Colors for Isolated Grounds: Green with white stripe.

C. Raceways and Cables Carrying Circuits at More Than 600 V:
   1. Black letters on an orange field.
   2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

D. Warning Label Colors:
   1. Identify system voltage with black letters on an orange background.

E. Warning labels and signs shall include, but are not limited to, the following legends:
   1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
   2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

F. Equipment Identification Labels:
   1. Black letters on a white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Panduit Corp.
      c. Seton Identification Products.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Panduit Corp.
      c. Seton Identification Products.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Brady Corporation.
   b. Brother International Corporation.
   c. Ideal Industries, Inc.
   d. Panduit Corp.
   e. Seton Identification Products.

2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.

3. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
   1. Minimum Nominal Size:
      a. 1-1/2 by 6 inches for raceway and conductors.
      b. 3-1/2 by 5 inches for equipment.
      c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters and that stay in place by gripping action.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Marking Services, Inc.
      c. Panduit Corp.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Panduit Corp.

2.5 TAPES AND STENCILS

A. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Carlton Industries, LP.
      c. Marking Services, Inc.
B. Tape and Stencil: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background and is 12 inches wide. Stop stripes at legends.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. LEM Products Inc.
      b. Marking Services, Inc.
      c. Seton Identification Products.

C. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Carlton Industries, LP.
      b. Seton Identification Products.

D. Underground-Line Warning Tape:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Ideal Industries, Inc.
      c. Marking Services, Inc.
      d. Seton Identification Products.
   2. Tape:
      a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
      b. Printing on tape shall be permanent and shall not be damaged by burial operations.
      c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
   3. Color and Printing:
      b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
      c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".
   4. Tag:
      a. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
      b. Width: 3 inches.
      c. Overall Thickness: 8 mils.
      d. Foil Core Thickness: 0.35 mil.
      e. Weight: 34 lb/1000 sq. ft.
      f. Tensile according to ASTM D 882: 300 lbf and 12,500 psi.

E. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.
2.6 TAGS

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Carlton Industries, LP.
      c. Marking Services, Inc.
      d. Seton Identification Products.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.023 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Marking Services, Inc.
      c. Panduit Corp.
      d. Seton Identification Products.

C. Write-on Tags:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Carlton Industries, LP.
      b. Seton Identification Products.
   2. Polyester Tags: 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment.
   3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
   4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Baked-Enamel Signs:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Carlton Industries, LP.
      b. Marking Services, Inc.
   2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
   3. 1/4-inch grommets in corners for mounting.

B. Laminated Acrylic or Melamine Plastic Signs:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
b. Carlton Industries, LP.
c. Marking Services, Inc.

2. Engraved legend.

3. Thickness:
   a. For signs up to 20 sq. in., minimum 1/16 inch thick.
   b. For signs larger than 20 sq. in., 1/8 inch thick.
   c. Engraved legend with black letters on white face.
   d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
   e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Ideal Industries, Inc.
   2. Marking Services, Inc.
   3. Panduit Corp.

B. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
   2. Tensile Strength at 73 Deg F according to ASTM D 638: 7000 psi.
   3. UL 94 Flame Rating: 94V-0.
   4. Temperature Range: Minus 50 to plus 284 deg F.
   5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer’s wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.

H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.


J. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
   1. "EMERGENCY POWER."
   2. "POWER."

M. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

N. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Labels:
   1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
   2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

P. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

Q. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

R. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.
S. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

T. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

U. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer’s written instructions.

V. Underground Line Warning Tape:
   1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
   2. Install underground-line warning tape for direct-buried cables and cables in raceways.

W. Metal Tags:
   1. Place in a location with high visibility and accessibility.

X. Nonmetallic Preprinted Tags:
   1. Place in a location with high visibility and accessibility.

Y. Write-on Tags:
   1. Place in a location with high visibility and accessibility.

Z. Baked-Enamel Signs:
   1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
   2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

AA. Laminated Acrylic or Melamine Plastic Signs:
   1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
   2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

BB. Cable Ties: General purpose, for attaching tags, except as listed below:
   1. Outdoors: UV-stabilized nylon.
   2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
   1. Locate identification at changes in direction, at penetrations of walls and floors, and at 10-foot maximum intervals.

D. Accessible Raceways and Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.
   1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

E. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:
   1. "EMERGENCY POWER."
   2. "POWER."
   3. "FIRE ALARM"

F. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use snap-around color-coding bands to identify the phase.
   1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

G. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.

H. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.

I. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes with the conductor designation.

J. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

K. Auxiliary Electrical Systems Conductor Identification: Marker tape that is uniform and consistent with system used by manufacturer for factory-installed connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

L. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

M. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:
   1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
   2. Wall surfaces directly external to raceways concealed within wall.
   3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

N. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and
29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

O. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

P. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.
   1. Apply to exterior of door, cover, or other access.
   2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
      a. Power-transfer switches.
      b. Controls with external control power connections.


R. Main Electrical Room: Framed with glass protective cover a full size drawing of project electrical single line diagram including all Project Record changes wall. Where multiple drawings are included in construction documents provide one for each sheet.

S. Operating Instruction Signs: Self-adhesive labels.

T. Emergency Operating Instruction Signs: Baked-enamel warning signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

U. Equipment Identification Labels:
   1. Indoor Equipment: Laminated acrylic or melamine plastic sign.
   2. Outdoor Equipment: Stenciled legend 4 inches high.
   3. Equipment to Be Labeled:
      a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of an engraved, laminated acrylic or melamine label.
      b. Enclosures and electrical cabinets.
      c. Access doors and panels for concealed electrical items.
      d. Switchboards.
      e. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
      f. Substations.
      g. Emergency system boxes and enclosures.
      h. Enclosed switches.
      i. Enclosed circuit breakers.
      j. Enclosed controllers.
      k. Variable-speed controllers.
      l. Push-button stations.
      m. Power-transfer equipment.
      n. Contactors.
      o. Remote-controlled switches, dimmer modules, and control devices.
      p. Power-generating units.
      q. Monitoring and control equipment.

END OF SECTION
SECTION 260572 - OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.3 DEFINITIONS
   A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
   B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
   C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
   D. SCCR: Short-circuit current rating.
   E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS
   A. Product Data: For computer software program to be used for studies.
   B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
      1. Short-circuit study input data, including completed computer program input data sheets.
      2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
         a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
         b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.
1.5 INFORMATIONAL SUBMITTALS
A. Qualification Data: For Short-Circuit Study Specialist.
B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.6 QUALITY ASSURANCE
A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
B. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
C. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE
A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. SKM Systems Analysis, Inc.
B. Comply with IEEE 399 and IEEE 551.
C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS
A. Executive summary.
B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.
C. One-line diagram, showing the following:
1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to short-circuit ratings.
   2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
   3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
   4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
   5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.


G. Short-Circuit Study Output:
   1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
      a. Voltage.
      b. Calculated fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. Equivalent impedance.
   2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
      a. Voltage.
      b. Calculated symmetrical fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. Calculated asymmetrical fault currents:
         1) Based on fault-point X/R ratio.
         2) Based on calculated symmetrical value multiplied by 1.6.
         3) Based on calculated symmetrical value multiplied by 2.7.
   3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
      a. Voltage.
      b. Calculated symmetrical fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. No AC Decrement (NACD) ratio.
      e. Equivalent impedance.
      f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
      g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Obtain all data necessary for the conduct of the study.
   1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

3. For relocated equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

2. Obtain electrical power utility impedance at the service.

3. Power sources and ties.

4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.

5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.

6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.

7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.

8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.

9. Motor horsepower and NEMA MG 1 code letter designation.

10. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.

2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

F. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

G. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
   1. Pad mounted transformer.
   2. Incoming switchboard.
   3. Distribution panelboards.
   4. Panelboards
   5. Control panels.
   8. Disconnect switches.

3.3 ADJUSTING

   A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

3.4 DEMONSTRATION

   A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION
SECTION 260573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1.3 DEFINITIONS
A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
D. SCCR: Short-circuit current rating.
E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS
A. Product Data: For computer software program to be used for studies.
B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
   1. Coordination-study input data, including completed computer program input data sheets.
   2. Study and equipment evaluation reports.
   3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
      a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Coordination Study Specialist Field Adjusting Agency.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01785 "Operation and Maintenance Data," include the following:
   a. The following parts from the Protective Device Coordination Study Report:
      1) One-line diagram.
      2) Protective device coordination study.
      3) Time-current coordination curves.
   b. Power system data.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. SKM Systems Analysis, Inc.
B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:
   a. Arcing faults.
   b. Simultaneous faults.
   c. Explicit negative sequence.
   d. Mutual coupling in zero sequence.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Cable size and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."

F. Protective Device Coordination Study:
   1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
      a. Phase and Ground Relays:
         1) Device tag.
         2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
         3) Recommendations on improved relaying systems, if applicable.
      b. Circuit Breakers:
         1) Adjustable pickups and time delays (long time, short time, ground).
         2) Adjustable time-current characteristic.
         3) Adjustable instantaneous pickup.
         4) Recommendations on improved trip systems, if applicable.
      c. Fuses: Show current rating, voltage, and class.

G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists
between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
   a. Medium-voltage equipment overcurrent relays.
   b. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
   c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
   d. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
   e. Cables and conductors damage curves.
   f. Ground-fault protective devices.
   g. Motor-starting characteristics and motor damage points.
   h. Generator short-circuit decrement curve and generator damage point.
   i. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Series rating on equipment is not allowed.
6. Provide adequate time margins between device characteristics such that selective operation is achieved.
7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
   1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
B. Comply with IEEE 399 for general study procedures.
C. The study shall be based on the device characteristics supplied by device manufacturer.
D. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
   1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

F. Transformer Primary Overcurrent Protective Devices:
   1. Device shall not operate in response to the following:
      a. Inrush current when first energized.
      b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
      c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
   2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

G. Motor Protection:
   1. Select protection for low-voltage motors according to IEEE 242 and CEC 70.
   2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

H. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

I. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

J. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
   1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

K. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
   1. Collage utility's supply termination point.
   2. Medium Voltage switch.
   3. Pad mount transformer.
   4. Low-voltage switchboard.
   5. Distribution panelboard.

L. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to short-circuit ratings.
   2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
   3. Any application of series-rated devices shall be allowed.
3.3 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:
   1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
   2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
   3. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded or might become overloaded; show bus voltages that are less than as prescribed by CEC 70.

3.4 MOTOR-STARTING STUDY

A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.

B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.

3.5 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.
   1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
   2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
   3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
   1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
   2. Electrical power utility impedance at the service.
   3. Power sources and ties.
   4. Short-circuit current at each system bus, three phase and line-to-ground.
   5. Full-load current of all loads.
   6. Voltage level at each bus.
   7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
17. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
   b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
   c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
   d. Generator thermal-damage curve.
   e. Ratings, types, and settings of utility company's overcurrent protective devices.
   f. Special overcurrent protective device settings or types stipulated by utility company.
   g. Time-current-characteristic curves of devices indicated to be coordinated.
   h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
   i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
   j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
   k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.6 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
B. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.7 DEMONSTRATION

A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:
   1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
   2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
   3. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION
SECTION 260574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.
   1. Arc-flash study input data, including completed computer program input data sheets.
   2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
      a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Specialist.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:
   1. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
   2. Operation and Maintenance Procedures: In addition to items specified in Section 017823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
   1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. SKM Systems Analysis, Inc.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Cable size and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."

F. Arc-Flash Study Output:
   1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
      a. Voltage.
      b. Calculated symmetrical fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. No AC Decrement (NACD) ratio.
      e. Equivalent impedance.
      f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
      g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

G. Incident Energy and Flash Protection Boundary Calculations:
   1. Arcing fault magnitude.
   2. Protective device clearing time.
   3. Duration of arc.
   5. Working distance.
   6. Incident energy.

H. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
   1. Location designation.
   2. Nominal voltage.
3. Flash protection boundary.
5. Incident energy.
7. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies:
   1. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."

C. Calculate maximum and minimum contributions of fault-current size.
   1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
   2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
   1. Fault contribution from induction motors should not be considered beyond three to five cycles.
   2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
   2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
   3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
   1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
   2. Obtain electrical power utility impedance at the service.
   3. Power sources and ties.
   4. Short-circuit current at each system bus, three phase and line-to-ground.
   5. Full-load current of all loads.
   6. Voltage level at each bus.
   7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
   8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
   9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
  10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
  11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
  12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
  13. Motor horsepower and NEMA MG 1 code letter designation.
  14. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
  15. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
3.4 LABELING

A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:
   1. Pad mount transformer
   2. Low-voltage switchboard.
   3. Distribution panelboards.
   4. Medium-voltage switch.
   5. Control panel.
   6. Standby generator and ATS.
   7. Panelboards.

3.5 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.6 DEMONSTRATION

A. Engage the Arc-Flash Study Specialist to train Owner’s maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION
SECTION 26 08 00 – COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes:

1. Section includes requirements for furnishing all labor, materials, and technical supervision to perform training for equipment and special systems described herein.
2. Electrical Systems Commissioning consists of static checks of component and system installations and actual testing of equipment conditions and functions.
3. Section specifies that Contractor shall engage the services of a recognized independent testing company for performing final inspections and tests as specified.
4. The testing company shall provide all material, test instruments, equipment, labor, and technical supervision to perform such tests and inspections.
5. It is the intent of these tests to verify that electrical equipment is operational within industry and manufacturer’s tolerances, and is installed in accordance with these specifications.
6. Perform tests, calibration, adjustment of relays and inspections before energizing any equipment.
7. Upon completion of the tests and inspections specified, a label shall be provided in accordance with NETA labeling.
8. Relay settings shall be made using approved relay setting reports, arc-flash, short circuit and coordination studies.
9. Commissioning Authority will review and approve, prior to use, all test procedures and forms used and will witness a varying fraction of the initial checks and testing performed by the Subcontractor. The Commissioning Authority will review the completed check and test documentation of the Subcontractor of all checks and tests.
10. The test requirements listed in this section do not release the Subcontractor from the obligation to perform all other appropriate, industry standard, manufacturer-recommended or code-required checks and tests.

B. Related Requirements:

1. Division 260553 Section “Overcurrent Protective Device Short Circuit Study” for Minimum fault current levels at equipment.
2. Division 260573 Section “Overcurrent Protective Device Coordination Study” for Device coordination settings.
3. Division 260574 Section “Overcurrent Protective Device Arc-Flash Study” for PPE signage and requirement labeling.
4. Division 26 Section “Lighting Controls” for lighting control sequence of operation requirements.
5. Division 262713.05 Section “Electricity Metering – M&V”.
6. Division 263213 Section “Diesel Emergency Engine Generators”

1.3 DEFINITIONS

A. Commissioning Authority (CA)

B. Certified Testing Agency (CTA)

1.4 QUALITY ASSURANCE

A. Referenced Standards:

1. OSHA Part 1910; Subpart S. 1910.308.
2. American National Standards Institute: ANSI
4. Association of Edison Illuminating Companies: AEIC
5. Institute of Electrical and Electronics Engineers: IEEE
6. Insulated Cable Engineers Association: ICEA
7. National Electrical Manufacturers Association: NEMA
9. National Fire Protection Association (NFPA)

B. All inspections and tests shall use the following references.

2. Drawings.
3. Manufacturer’s instruction manuals and approved shop drawings for applicable equipment.

C. Certified Testing Agency Qualifications: Member Company of NETA or an NRTL.

1.5 COMMON RESPONSIBILITY

A. The following are responsibilities applicable to all electrical systems being commissioned.

B. The general commissioning requirements and coordination in Division 01 apply to electrical systems. The Subcontractor shall be familiar with all parts of Division 01 commissioning requirements and the commissioning plan issued by the Commissioning Authority and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

C. The work of this section shall be performed by a Certified Testing Agency, Electrical, by the contractor, or the manufacturer’s service representative. The Commissioning Authority has some testing responsibilities for some equipment. The specified checks and static tests are conducted by any of the above listed parties, but the tests requiring measurements or special tools or skills are generally conducted only by the CTA. The Check and Testing Responsibility Table, included as a supplement to Division 01 Section “General Commissioning Requirements” provides specific allocation of checklist oversight and testing responsibilities. The Certified Testing Agency, Electrical Contractor, and Manufacturers Service Representative shall
document all checks and testing on check and test procedure forms submitted to and approved by the Commissioning Authority prior to testing.

D. Contractor shall notify the Construction Manager, Owner and Architect when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling.

E. The Contractor or Commissioning Authority shall notify the Construction Manager, Architect and Owner ahead of time when commissioning activities not yet performed or not yet scheduled will delay construction. The Contractor and Commissioning Authority shall be proactive in seeing that commissioning processes are executed and that the Contractor or Commissioning Authority has the scheduling information needed to efficiently execute the commissioning process.

F. Certified Testing Agency shall notify the Construction Manager a minimum of two weeks before commencement of testing.

G. Certified Testing Agency and Contractor shall be responsible for implementing final settings and adjustments on protective devices with contractor’s assistance.

H. The Contractor shall respond to notices of issues identified during the commissioning process, making require corrections or clarifications and returning prompt notification to the Commissioning Authority.

I. When completion of a task or other issue has been identified as holding up any commissioning process, particularly functional testing, the contractor shall, within two (2) days of notification of the issue, notify the Commissioning Authority in writing providing an expected date of completion. The contractor shall notify the Commissioning Authority in writing within one day of completion. It is not the responsibility of the Commissioning Authority to obtain this status information through meeting attendance, asking questions or field observation.

J. Construction Checklists. The Commissioning Authority or Contractor shall develop checklists. At a minimum, for a given piece of equipment, checks from the inspection checklists in NETA Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems shall be included in the electrical checklists. The contractor shall execute and document all checks.

K. Check and testing procedure and startup plan development and execution responsibilities are described in the Check and Testing Responsibility Table.

L. The contractor shall review design documents, shop drawings and Operation and Maintenance manuals and manufacturer recommended installation and testing procedures of each system installation.

M. The contractor shall monitor installation to ensure the equipment, configuration and quality of construction meets the design requirements, approved submittals and shop drawings.

N. Certified Testing Agency and Contractor shall maintain a written record of tests and upon completion of the work, assemble and certify a final test report. A final test report shall be submitted to the Construction Manager for review and comment before the final report is submitted.

1.6 CHECK AND TESTING RESPONSIBILITY TABLE.
A. Column heading Key

1. Submittal Review: Review submittals of commissioned equipment for either information to assist in test writing and field verification (designated by an (i) in the table), or for a more thorough review to make comments parallel with the A/E reviews (r).
2. Field Observation: General observation of installation to become familiar with equipment and secondarily to identify problems.
3. Perform and Document Checklists: The first indicated party is responsible to execute the check-lists and document each line item. The Commissioning Authority spot-witnesses check listing and startup and reviews the completed versions (reports). Any Construction Checklists or Startup Plans developed by the Commissioning Authority are reviewed by the Trade Subcontractors and visa-versa prior to execution.
4. Prepare Test Procedures: Develop the written step-by-step test procedures and documentation forms for mechanical systems. For electrical component tests these procedures may be more checklist in nature and not include all specific procedural details, though all measurements will be recorded.
   a. Ensure that tests are scheduled and coordinated with the interfaces to other systems and requirements of the authorities having jurisdiction.
   b. Develop a logical test plan that flows from the component level on the various systems to the integrated testing of the systems as they interact with each other.
   c. Direct the order that test procedures are conducted. Coordinate and manage the parties participating in the testing.
   d. Verify that all necessary documentation requirements are met for all parties including but not limited to authorities having jurisdiction, the Owner, the Commissioning Authority and the insurance underwriter.
   e. Facilitate effective communication and coordination across trades and disciplines as required for successful integrated testing of systems and assemblies.
   f. Witness entire test and fully document on approved forms the methods, procedures and results of each test procedure of all tests.
6. Perform Test: Manipulate equipment or systems or set up and initiate actions on assemblies that demonstrates function and performance.
7. Witness: (See also applicable footnotes.)
   a. Spot: (s) in the table. Spot witnessing of testing shall include a large enough sample to provide reasonable confidence that the tests were conducted properly. Sampling may be random or focused as determined by the Commissioning Authority. For selected systems such as Overcurrent devices coordination and arc-flash labeling, spot witnessing may only require reviewing means and methods at the beginning of the test and a review of the test report.
   b. All: (a) in the table. Witness the duration of all test procedures performed. Note that for some systems where there is a sampling strategy, not all systems will be tested, but all that are tested, will be witnessed. Refer to the testing requirements in the referenced Sections for details.
   c. Witnessing does not necessarily include documenting of individual test or observation results, but does include recording attendance and general results.
8. Prepare Test Report: Assembly and review the testing documentation. Report information could be gathered and incorporated into final report by Commission Agent or in some cases documented by commissioning agent.
B. The contractor shall develop test procedures and forms and execute and document testing according to the requirements of this Section, Division 01, and other specification sections containing testing requirements.

C. Tests of energized equipment shall be conducted when the equipment is operating at its normal capacity. This may require some tests to be conducted after occupancy.

D. Training and Orientation. The Subcontractor shall follow the facility staff orientation and training requirements as described in Division 01 Section “Demonstration and Training” and other applicable technical sections.

E. Operation And Maintenance (O&M) Manuals. Refer to Division 01 Section “General Commissioning Requirements” and Division 01 Section “General Requirements” for requirements for O&M manuals. Contractor shall perform routine insulation resistance, continuity and rotation tests for distribution and utilization equipment before tests performed by the testing company specified.

<table>
<thead>
<tr>
<th>System</th>
<th>Components</th>
<th>Submittal Review</th>
<th>Field Observation</th>
<th>Perform and Document Check Lists</th>
<th>Prepare Test Procedures</th>
<th>Oversee and Documentation</th>
<th>Perform Test</th>
<th>Witness</th>
<th>Prepare Test Reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium Voltage Cables</td>
<td>All</td>
<td>i/CA, r/AE</td>
<td>CA</td>
<td>CA</td>
<td>CA</td>
<td>CTA</td>
<td>a/CA</td>
<td>CTA</td>
<td></td>
</tr>
<tr>
<td>Grounding</td>
<td>Main Electrical Room and Ground Rods</td>
<td>i/CA, r/AE</td>
<td>CA</td>
<td>CA</td>
<td>CA</td>
<td>CTA</td>
<td>a/CA</td>
<td>CTA</td>
<td></td>
</tr>
<tr>
<td>Fault Current Ratings</td>
<td>All Switch gear</td>
<td>i/CA, r/AE</td>
<td>CA, EC</td>
<td>EC</td>
<td>CA</td>
<td>s/CA</td>
<td>EC, CTA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protective Device Settings</td>
<td>All Protective Devices &gt; 250 Amp</td>
<td>AE</td>
<td>CA, AE</td>
<td>CA</td>
<td>CA, MSR</td>
<td>CA, MSR</td>
<td>s/CA, a/MSR</td>
<td>CTA</td>
<td></td>
</tr>
<tr>
<td>Arc-Flash</td>
<td>All Electrical Equipment</td>
<td>i/CA</td>
<td>CA</td>
<td>EC</td>
<td>CA</td>
<td>s/CA</td>
<td>EC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Power Monitoring and Control</td>
<td>All</td>
<td>i/CA, i/CC</td>
<td>CA</td>
<td>CA</td>
<td>CA</td>
<td>CTA</td>
<td>a/CA</td>
<td>CTA</td>
<td></td>
</tr>
<tr>
<td>Lighting Control Stations</td>
<td>All</td>
<td>i/CA</td>
<td>CA, AE</td>
<td>CA</td>
<td>CA</td>
<td>CTA</td>
<td>s/CA</td>
<td>CTA</td>
<td></td>
</tr>
<tr>
<td>Lighting Occupancy Sensors</td>
<td>All</td>
<td>i/CA</td>
<td>CA, AE</td>
<td>CA</td>
<td>CA</td>
<td>CTA</td>
<td>s/CA</td>
<td>CTA</td>
<td></td>
</tr>
<tr>
<td>Lighting Daylight Sensors</td>
<td>All</td>
<td>i/CA</td>
<td>CA, AE</td>
<td>CA</td>
<td>CA</td>
<td>CTA</td>
<td>s/CA</td>
<td>CTA</td>
<td></td>
</tr>
</tbody>
</table>
### TEST INSTRUMENT SERVICE AND CALIBRATION

#### A. Calibration Program and Accuracy:

1. Certified Testing Agency shall have a calibration program that maintains applicable test instrumentation within rated accuracy in accordance with manufacturer’s recommendations and standard industry practice.
2. The accuracy shall be traceable to the National Bureau of Standards (NBS) in an unbroken chain.
3. Instruments shall be calibrated in accordance with the following frequency schedule:
   
   a. Field instruments: 6 months, maximum.
   b. Laboratory instruments: 12 months.
   c. Leased specialty equipment: 12 months (where accuracy is guaranteed by the lessor)

---

**Abbreviations:**

- A/E: Designer
- CA: Commissioning Authority
- TC: Trade Subcontractor providing equipment
- CC: Controls Contractor
- EC: Electrical Contractor
- CTA: Certified Testing Agency
- MC: Mechanical Contractor
- MSR: Manufacturer Service Representative
- TAB: Testing, Adjusting and Balancing contractor.
4. Dated calibration labels shall be visible on test equipment.

B. Safety and Precautions:

1. Safety practices shall include, but are not limited to, the following requirements.
   a. OSHA
   c. Applicable State and local safety operating procedures.

2. Acceptance tests shall be performed with apparatus de-energized, unless otherwise specified.

3. Certified Testing Agency shall have a designated safety representative who shall be present on the Project and supervise operations with respect to safety.

4. Circuits operating in excess of 600-volts between conductors shall have conductors shorted to ground by a hot-line grounded device UL approved for the purpose.

5. Work shall not proceed until the safety representative has determined that it is safe to do so.

6. Certified Testing Agency shall have available sufficient protective barriers and warning signs. The testing agency shall place the protective barriers and warning signs in close proximity to the area where testing is being performed.

C. DEFINITION OF TESTS


2. Electrical Startup Tests: Those inspections and tests required to show that the workmanship, methods, inspections, and materials used in erection and installation of the electrical equipment conforms to accepted engineering practices, IEEE Standards, the National Electrical Code, manufacturers instructions, and Electrical Work of this Contract, and to determine that the equipment involved may be energized for operational tests.

3. Operating Tests: Those tests performed on all electrical equipment installed as part of the Electrical Work of the Contract and under other sections of the Specifications, to show that the electrical equipment will perform the functions for which it was designed.

1.8 AUTHORIZED WITNESSES

A. Perform all acceptance, startup and operating tests in the presence of the Construction Manager, Architect and Owner or designated authorized witness.

B. Notify vendors and manufacturers of electrical equipment of the time of tests. Coordinate with them or their representatives to permit them to witness tests should they so request.

1.9 DATA TO BE RECORDED

A. Maintain reproducible test data sheets showing results of tests described in the accepted test procedures. Provide reproducible data sheets, listing acceptable or specified test limits and
values actually measured. Retain one copy of test data sheets at the site. Furnish four copies to the Construction Manager.

B. Provide data sheets showing test set-up, equipment used, names of persons performing test, names of witnesses, date, location, and serial number of equipment under test. Test data sheets will be reviewed by the Construction Manager and accepted as submitted, or additional tests may be required. If additional tests are required because initial test results do not comply with Specifications, document the re-testing and submit as before at no additional cost to BSDA.

1.10 ACTION SUBMITTALS

A. Submit proposed testing program and test procedures for review and approval by the Construction Manager before beginning any testing. Each procedure shall include the following as a minimum:

1. Statement of procedure objective and scope.
2. List of equipment required to set up and perform the procedure.
3. List of equipment or services required from areas outside Contractor’s control.
4. List of prerequisite tests that need to be completed before the procedure can be performed.
5. Description of the required procedure setup, including diagrams illustrating test equipment connections and identifying test points, where applicable.
6. Step-by-step instructions for performing the procedure identifying the points where data is to be recorded and the limits for acceptable data, in accordance with referenced standards.
7. Provisions for recording pertinent test conditions and environment at time of test.
8. Instructions for recording data on data sheets and verifying that procedure steps have been completed.

B. Test Report (Draft and Final)

1. The draft and final test reports, shall include, but not be limited to, the following:

   a. Summary of Project.
   b. Description of equipment tested.
   c. Description of test.
   d. List of test equipment used in calibration and calibration date.
   e. Test results, including plots/graphs and actual readings/measurements taken including corrected values.
   f. Conclusions and recommendations.
   g. Appendix, including appropriate test forms.
   h. All test reports shall be signed by the Construction Manager’s authorized witness present at the test.

2. The final test report shall be bound and its contents certified.
3. Furnish ten copies of the completed final test report to the Construction Manager no later than 15 days after completion of the inspection and testing.

C. Instruments: Submit list of instruments and certification indicating that instruments that will be used for testing have been calibrated and their accuracy certified within a previous period of not more than one month. List types of instruments to be used, manufacturer, model, serial number, latest date of calibration, and calibration organization.
1.11 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency and the resumes of the personnel proposed to be assigned to this Project.

B. Data gathering check lists and forms.

C. Product Test Reports: For each, for tests performed by manufacturer and witnessed by a qualified testing agency.

D. Evaluation Reports: For equipment identified on the check and testing responsibility table, from ICC-ES.

E. Pretesting observation Reports: For equipment identified on the check and testing responsibility table.

F. Source quality-control reports.

G. Field quality-control reports.

1.12 CLOSEOUT SUBMITTALS

A. Final Commissioning Data: For equipment identified on the check and testing responsibility table to include in maintenance manuals.

B. Final Commissioning Report Data: For equipment identified on the check and testing responsibility table to include in emergency, operation, operation and maintenance manuals.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine, with Installer present, for compliance with requirements for installation tolerances and construction documents and other conditions affecting performance of the Work.

B. Examine equipment identified on the check and testing responsibility table before installation. Reject that are damaged, incomplete installation, or incorrect application or installation.

C. Proceed with testing and commissioning only after unsatisfactory conditions have been corrected.

3.2 TESTING REQUIREMENTS

A. Do not perform more than one high potential test on any conductor unless specifically authorized by the CM.
B. Megger Tests

1. Megger readings specified are the minimum readings desired at an ambient temperature of 60-degrees F and at a relative humidity of less than 60-percent. When megger readings are taken at other than 60-degrees F, convert readings to equivalent values at 60-degrees F.

2. When megger readings fall below the specified minimum values at 60-degrees F, devise some means of applying heat for drying out the equipment subject to the approval of the Construction Manager. If drying is to be done by applying an electric potential to a piece of equipment, do not exceed the continuous voltage or current ratings of the equipment being dried, directly or by induction.

C. Continuity Tests: Perform continuity tests with a dc type device using a bell, buzzer, or multimeter. Do not use telephones for continuity tests; use telephones only for communication.

D. Restore all connections and equipment to operating conditions after testing has been completed.

3.3 TESTS ON CONDUCTORS RATED 600 VOLT AND BELOW

A. General: Provide and record all power feeder and branch circuit except feeders to individual HVAC equipment or motors conductor a continuity test and a megger test. Verify phase identification on each power feeder and branch circuit.

B. Verify identification of all lighting circuits and branch circuits on panel directories and make operational checks on all lighting circuits and branch circuits to prove that the circuits perform all functions for which they are designed.

C. Check all feeder and subfeeder cable connections for workmanship and conformance with standard practice by visual inspection.

D. Visual and mechanical inspection

1. Conductors shall be inspected for physical damage and proper connection in accordance with single line diagram.

2. Conductors connections shall be torque tested to manufacturer’s recommended values.

E. Connections: Isolate power conductor to be megger tested by opening switches or breakers at each end of cable before testing where such disconnecting means exists. Where cables are direct connected without a disconnecting means, do not disconnect cables: Test as connected.

F. Megger Tests

1. Use a 1,000-volt megger for each megger test. Insulation resistance tests shall be performed at 1,000-volts dc for 30 seconds.

2. Apply megger tests between each conductor and ground with the other two conductors in the conduit or cable grounded to the same ground. Test each conductor in the same manner.

3. Minimum acceptable readings: For disconnected cables, 100-megohm.

4. When insulation resistance is to be determined with all switchboards, panelboards, fuse holders, switches, and overcurrent devices in place, the insulation resistance when tested at 500-volts dc shall be no less than indicated in Table "Minimum Insulation Resistance".
G. Acceptance: Cable that do not pass all inspections and tests shall be considered defective and must be replaced and retested.

H. Records: Include the following information in test report on each power feeder and branch circuit cable rated below 600-volts:

2. Megger readings, including converted values.
3. Approximate average cable temperature.

<table>
<thead>
<tr>
<th>Minimum Insulation Resistance</th>
<th>Minimum Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor or Circuit Size</td>
<td></td>
</tr>
<tr>
<td>No. 14 &amp; No. 12 AWG</td>
<td>1,000,000-ohms</td>
</tr>
<tr>
<td>25-ampere circuits &amp; above</td>
<td>250,000-ohms</td>
</tr>
</tbody>
</table>

3.4 TESTS ON CONTROL WIRING

A. General: Give each single conductor and multi-conductor control wire or cable a continuity tests and an insulation strength test. Verify identification of conductors.

B. Connections: Disconnect and fan out conductors to be tested.

C. Insulation Strength Tests

1. Subject each control wire to a 500-volt, 60-Hertz test.
2. Apply test between each conductor in a wire group and ground with all other conductors in the wire group grounded to the same ground. Use a test set having an accurate means of insuring 500-volt test voltage and provide a series resistance to limit fault when a ground is found. Hold test voltage only long enough to read instruments. Test each conductor in the same manner.
3. Instead of the above insulation strength test, megger each control wire as specified for 600-volt and below power conductors.
4. Acceptance: Control wiring conductors that do not pass all inspections and tests shall be considered defective and must be replaced and retested.

D. Records: Include the following information in test report on each wire group.

1. Wire and group identification.
2. Type of test, insulation strength or megger.
3. When megger testing is selected, include information as specified for conductors rated 600 volt and below.

3.5 TESTS ON TRANSFORMERS RATED 600 VOLTS AND BELOW

A. General: Check continuity and correctness of connections of windings and give each winding a megger test.

1. Visual and mechanical inspection

   a. Inspect for physical damage.
   b. Compare equipment nameplate information with latest single line diagram and report discrepancies to the Construction Manager.
c. Verify proper auxiliary device operation for components including, but not limited to, fans, indicators, and tap changer.
d. Check tightness of accessible bolted electrical joints in accordance with Table 3.7.1. Check hardware, bushings, and vibration mats.
e. Perform specific inspections and mechanical tests in accordance with the manufacturer’s instructions.

B. Connections: Isolate transformer by opening the line side circuit breaker and disconnect secondary conductors at panels. Tie conductors together on each winding.

C. Megger Tests

1. Use a 1,000-volt megger for megger tests on 480-volt windings and a 500-volt megger for megger tests on lesser voltage windings. Appropriate guard circuit shall be used under bushings.
2. Apply a megger test between each transformer winding tied together and ground. Ground all windings not included in the test to the same ground. Winding resistance tests shall be made for each winding at nominal tap position. Perform a megger test of the secondary windings.
3. Minimum acceptable readings: 480-volt winding to ground, 45-megohms; lesser voltage winding to ground, 30-megohms.
4. Hold all megger tests for at least one minute or until the reading maintains a constant value for 15 seconds.

D. Electrical tests

1. A dielectric absorption test shall be made winding to winding and winding to ground for ten minutes. The polarization index shall be computed.
2. A turn ratio test shall be performed between windings for all tap positions. The final tap setting shall be determined and set by the testing company upon completion of the ratio testing acceptable values.
3. AC over-potential test shall be made on all high and low voltage winding to ground.
4. Individual exciting current tests shall be performed on each phase in accordance with established procedure.
5. Perform special test and adjustments in accordance with the manufacturer’s instructions for tap changer, fan and controls, and alarm functions.
6. Perform a double power factor excitation test with a 10-kV tester.
7. Perform a core ground test.
8. Test temperature control panel and verify alarm stages and interlock for shutdown.

E. Test values

1. Insulation resistance and absorption test voltage shall be in accordance with Table "Insulation Resistance Test Voltage". Results shall be temperature corrected.
2. The absorption test polarization index shall be above 2.0 unless an extremely high value is obtained at the end of 1 minute, that when doubled will not yield a meaningful value with the available test equipment.
3. AC high potential test voltage shall not exceed 75-percent of factory test voltage or Table "Insulation Resistance Test Voltage" for a one-minute duration. Evaluation shall be on go, no-go, basis; NEMA ST-20.
4. Power factor test values more than 3-percent shall be investigated.
5. Winding resistance test results shall compare within 1-percent of adjacent windings.
6. Turns ratio test results shall not deviate more than 0.50 percent from calculated ratio.
F. Acceptance: Transformers that do not pass all inspections and tests shall be considered deficient and shall be replaced and retested.

G. Records: Make complete and accurate records of each test. Include the following in each test report:

2. Megger readings, including converted values and ambient temperature at time of test.

<table>
<thead>
<tr>
<th>Insulation Resistance Test Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Rating (Volts)</td>
</tr>
<tr>
<td>150 – 600</td>
</tr>
<tr>
<td>601 – 5,000</td>
</tr>
<tr>
<td>5,001 – 15,000</td>
</tr>
</tbody>
</table>

3. Values of insulation resistance (IR) less than manufacturer’s minimum or kV plus 1 in megohms shall be investigated. Over-potential tests shall not proceed until IR levels are raised to specified minimum.

4. Over-potential test voltages shall be applied in accordance with ANSI C37.20c, Table “Overpotential Test Voltages”.

<table>
<thead>
<tr>
<th>Overpotential Test Voltages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated kV</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>15</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>35</td>
</tr>
</tbody>
</table>

5. Test results are evaluated on a go, no-go basis by slowly raising the test voltage to the required value and applying the final test voltage for 1 minute.

<table>
<thead>
<tr>
<th>Table 3.13.3 – Applied Potential Test Voltages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nameplate Winding Voltage Rating, Volts</td>
</tr>
<tr>
<td>0 – 250</td>
</tr>
<tr>
<td>251 – 1,200</td>
</tr>
<tr>
<td>1,201 – 2,500</td>
</tr>
<tr>
<td>2,501 – 5,000</td>
</tr>
<tr>
<td>5,001 – 8,660</td>
</tr>
<tr>
<td>8,661 – 15,000</td>
</tr>
</tbody>
</table>

3.6 TESTS ON CIRCUIT BREAKERS, LOW VOLTAGE (MOLDED CASE)

A. Visual and mechanical inspection

1. Circuit breakers shall be checked for proper mounting, conductor size, and feeder designation.
2. Operate circuit breakers to insure smooth operation.
3. Inspect case for cracks and other defects.
4. Check tightness of connection with torque wrench in accordance with manufacturer’s instructions.
B. Electrical tests

1. Contact resistance shall be measured.
2. Time-current characteristic tests shall be performed by passing 300 percent rated current through each pole separately. Trip time shall be determined.
3. Instantaneous pickup current shall be determined by run-up or pulse method. Clearing times shall be within 4-cycles or less.
4. Insulation resistance shall be determined pole to pole, across pole and pole to ground. Test voltage shall be 1,000-volts DC.

C. Test Values

1. Contact resistance shall be compared to adjacent poles and similar breaker. Deviations of more than 50-percent shall be investigated.
2. Insulation resistance shall not be less than 50 megohms.
3. All trip times shall fall within Table 3.17.1. Circuit breakers exceeding maximum 300-percent time (Column 5) shall be replaced.
4. Instantaneous pickup current levels shall be within 20-percent of manufacturer’s published values.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>240</td>
<td>15 – 45</td>
<td>---</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>240</td>
<td>50 – 100</td>
<td>---</td>
<td>70</td>
<td>200</td>
</tr>
<tr>
<td>600</td>
<td>15 – 45</td>
<td>5</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>600</td>
<td>50 – 100</td>
<td>5</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>240</td>
<td>110 – 225</td>
<td>10</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>600</td>
<td>110 – 225</td>
<td>10</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>600</td>
<td>250 – 450</td>
<td>25</td>
<td>250</td>
<td>300</td>
</tr>
<tr>
<td>600</td>
<td>500 – 600</td>
<td>25</td>
<td>250</td>
<td>350</td>
</tr>
<tr>
<td>600</td>
<td>700 – 1,200</td>
<td>25</td>
<td>450</td>
<td>600</td>
</tr>
<tr>
<td>600</td>
<td>1,400 – 2,500</td>
<td>25</td>
<td>600</td>
<td>750</td>
</tr>
</tbody>
</table>

a. * These values are based on heat tests conducted by circuit breaker manufacturers on conductors in conduit.

3.7 TESTS ON INSTRUMENT TRANSFORMERS

A. Visual and mechanical inspection

1. Inspect for physical damage and compliance with the Drawings.
2. Check mechanical clearances and proper operations of all disconnecting and grounding devices associated with potential transformers.
3. Verify proper operation of grounding or shorting devices.
B. Electrical tests

1. Current transformers (CT) shall have secondary saturation tests done at a minimum of three points below and one point above knee of saturation curve.
2. Confirm transformer polarity electrically.
3. Burden tests shall be performed at the secondary leads of the CT to assure accurate translation of primary current.
4. Verify connection at secondary CT leads by driving a low current through the leads and checking for this current at applicable devices.
5. Confirm transformer ratio.
6. Measure insulation resistance of transformer secondary and leads with 500 volt Megohm meter.
7. Measure transformer primary insulation with applicable over-potential tests.
8. Verify connection of secondary potential transformer (PT) leads by applying a low voltage to the leads and checking for this voltage at applicable devices.
9. Check for PT secondary load with secondary voltage and current measurements. Load shall less than voltage ampere capacity of the PT.

3.8 TESTS ON METERING AND INSTRUMENTATION

A. Visual and mechanical inspection

1. Examine devices for broken parts, indication of shipping damage and wire connection tightness.
2. Verify meter connections in accordance with single line meter and relay diagram.

B. Electrical tests

1. Calibrate all meters at mid-scale. Calibration instrument precision shall be 50-percent or less than the precision of the instrument being tested. (If the instrument being tested has a precision of plus or minus 10-percent, the precision of the calibration instrument shall be plus or minus 5-percent or better.)
2. Calibrate watt-hour meters to 0.50-percent.
3. Verify instrument multipliers.

C. Acceptance: Grounding materials and connections must pass all inspections and must meet all specified maximum and minimum values.

D. Records: Make complete records of all tests. Include resistance values obtained, calculations of same, and methods of test and calculation.

3.9 TESTS ON GROUNDING SYSTEMS

A. General: Inspect ground conductors, ground buses, and connections for conformance with design specifications and for satisfactory workmanship. Test resistance to earth of each ground rod. Test ground paths for equipment and structural steel or reinforcing bar grounding.

1. Visual and mechanical inspection: Inspect ground system for compliance with the Drawings and specifications.

B. Connections
1. Maintain each ground rod isolated from the associated ground rods for tests on individual rods for resistance to earth.
2. Include associated ground rods and interconnecting wiring in test for resistance to earth.
3. Include ground bus on equipment, room and pullbox connections, and associated intermediate copper ground conductors in tests on ground paths for electrical equipment.
4. Include structural steel or reinforcing bar connection, rod connection and intermediate conductor in tests on ground paths for structural steel or reinforcing bars.

C. Electrical tests

1. Perform fall of potential test in accordance with IEEE 81, Section 9.04, on the main grounding electrode or system.
2. Perform the two-point method test in accordance with IEEE 81, to determine the ground resistance between the main grounding system and major electrical equipment frames, system neutral, and/or derived neutral points.
   a. Alternate method: Perform ground continuity test between main ground system and equipment frame, system neutral and/or derived neutral point. This test shall be made by passing a minimum of 10 amperes DC current between ground reference system and the ground point to be tested. Voltage drop shall be measured and resistance calculated by voltage drop method.

3. Tests on Individual Ground Rods
   a. Test each ground rod for resistance to earth by a standard method. Use a Biddle Ground Tester (AVO International) or the method of using two auxiliary ground rods as described in IEEE. The IEEE method requires the use of ac test current. Place auxiliary test rods sufficiently far away from the rod under test so that the regions in which their resistance is localized do not overlap. Calculate ground resistance from the readings taken. Maximum acceptable resistance to earth: 2-ohms.
   b. If the resistance is found to be higher than 2-ohms, drive additional rods with a minimum separation of 20-feet and connect in parallel with the rod under test until 2-ohms or less is obtained, or increase the length of the rod under test until 2-ohms maximum is obtained.

D. Tests of same, and methods of test and calculation.

3.10 TESTS ON SURGE ARRESTORS

A. Visual and mechanical inspection
   1. Inspect for physical damage.
   2. Verify location and nameplate rating with the Drawings and the specifications.
   3. Inspect ground and discharge counter connections for integrity.

B. Electrical tests
   1. Perform a 60-Hertz sparkover test.
   2. Perform a radio influence voltage (RIV) test.
   3. Perform an insulation power factor test.
   4. Perform ground continuity test to ground grid system.
C. Test values

1. Sparkover voltage shall:
   a. Exceed 1.5 times rating.
   b. Not exceed 2.0 times rating.

2. Radio influence voltage (RIV) shall not be detected within voltage rating of arrestor.
3. Power factor tests shall show similar dielectric loss between similar arrests.
4. Ground grid connections shall not exceed 0.5-ohms, maximum.

3.11 TESTS ON LIGHTING SYSTEMS – STATION AND BUILDINGS

A. Perform operation tests for complete lighting system including switches, emergency lighting, and receptacles.

3.12 SYSTEM FUNCTION TESTS

A. General

1. Each system specified shall be function tested to confirm total system operation.
2. Upon completion of equipment tests, the system functional tests shall be performed. System functional tests shall show the proper interaction of sensing, processing, and action devices to effect the design end-product or results.
3. Implementation
   a. The testing company shall develop a test matrix that includes, but is not limited to, the following:
      1) Input signal or stimuli. Example: Current transformers; potential transformers.
      2) Decision process. Example: Pilot Wire Relay System
      3) Action device. Example: Circuit Breaker – ACB
      4) End product or result. Example: Zone Fault Protection
   b. All interlocks safety devices and fail-safe functions shall be tested in addition to design function.
   c. The testing company shall propose methods to initiate the sensing device by physical stimuli and quantitatively monitor the result or output by measurement.

B. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain units.

END OF SECTION
SECTION 260913.01 - ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. The products specified herein are intended to provide a complete sub-metering solution. This solution shall be utilized to measure and monitor owner provided utilities including, but not limited to, electricity, gas, water, and Standby power. System will also allow for compliance with national and local energy codes and provide equipment needed to meet specific LEED M&V credits.

B. Electrical sub-metering equipment, data collection systems, and data management software systems including:
   1. Standard single point kWh electrical sub-meters
   2. Advanced single point kWh electrical sub-meters
   3. Multi-point electrical sub-meters
   4. Data collection hubs
   5. High density pulse modules
   6. Open protocol data communication network
   7. Wireless communication devices

C. Related Requirements:
   1. Section 255000 "Building Automation Hardware and Networking.

1.3 DEFINITIONS

A. Active Power: The average power consumed by a unit. Also known as "real power."

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. Apparent (Phasor) Power: "S = VI" where "S" is the apparent power, "V" is the rms value of the voltage, and "I" is the rms value of the current.

D. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

E. KY Pulse: A method of measuring consumption of electricity that is based on a relay operating like a SPST switch.

F. KYZ Pulse: A method of measuring consumption of electricity based on a relay operating like a SPDT switch.

G. LAN: Local area network.
H. L-G: Line to ground.
I. L-L: Line to line.
J. L-N: Line to neutral.
K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.
L. Modbus TCP/IP: An open protocol for exchange of process data.
M. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
N. N-G: Neutral to ground.
O. Power Factor: The ratio of active power to apparent power, sometimes expressed in percentage.
P. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.
Q. TCP/IP: Transport control protocol/Internet.
R. UPS: Uninterruptible power supply; used both in singular and plural context.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for power monitoring and control.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
B. Sustainable Design Submittals:
   1. Product Data: Indicating that computers used by the system are certified by ENERGY STAR.
C. Shop Drawings: For power monitoring and control equipment.
   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.
      a. Attach copies of approved Product Data submittals for products (such as switchboards, switchgear, and motor-control centers) that describe the following:
         1) Location of the meters and gateways, and routing of the connecting wiring.
         2) Details of power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.
   3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
   4. Network naming and numbering scheme.
5. Include diagrams for power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
7. Surge Suppressors: Data for each device used and where applied.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Design Data:
   1. Manufacturer’s system installation and setup guides, with data forms to plan and record options and setup decisions.
      a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format on compact disk or portable storage device with a USB interface.
      b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
      c. As-built versions of submittal Product Data.
      d. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for the system and products.
      e. Operator’s manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
      f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
      g. Engineering, installation, and maintenance manuals that explain how to do the following:
         1) Design and install new points, panels, and other hardware.
         2) Perform preventive maintenance and calibration.
         3) Debug hardware problems.
         4) Repair or replace hardware.
      h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
      i. Backup copy of graphic files, programs, and database on compact disk or portable storage device with a USB interface.
      j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
      k. Complete original-issue copies of furnished software, including operating systems, custom programming language, workstation software, and graphics software on compact disk or portable storage device with a USB interface.
      l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
      m. Owner training materials.

1.6 CLOSEOUT SUBMITTALS

A. Section 01785 “Operation and Maintenance Data”: For power monitoring and control units to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
2. Software licenses.
3. Software service agreement.
4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Provide separately for each PC.
5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on compact disk or portable storage device with a USB interface of the hard-copy submittal.
6. Program Software Backup: On compact disk or portable storage device with a USB interface, complete with data files.
7. Device address list.
8. Printout of software application and graphic screens.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Addressable Relays: One for every 10 installed. Furnish at least one of each type.
   2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.9 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Basis-of-Design Product: Subject to compliance with requirements, provide Leviton Verifeye Metering System or comparable product by one of the following:
   1. Eaton.
   2. General Electric Company.
   3. Schneider Electric USA, Inc.

B. Microprocessor-based monitoring and control of electrical power distribution system(s) that includes the following:
   1. Electrical meters that monitor, control, and connect to the data transmission network.
   2. LAN: High-speed, multi-access, open, nonproprietary, industry-standard communication protocols.
3. Include multiple PC-based workstations, with its operating system and application software, connected to data transmission network.
4. Monitoring and Verification of the following load types:
   a. Lighting interior and exterior loads.
   b. Receptacle plug loads.
   c. HVAC and Mechanical loads

C. The electrical power monitoring and control system shall be Internet based.
   1. System software shall be based on server thin-client architecture, designed around open standards of internet technology.
   2. Intent of thin-client architecture is to provide operators complete access to power monitoring and control system via an Internet browser. No special software other than an Internet browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
   3. Internet access shall be password protected.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

E. UL Compliance: Listed and labeled as complying with UL 61010-1.

2.2 PERFORMANCE REQUIREMENTS

A. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
   1. Minimum Protection for Power Lines 120 V and More: SPDs complying with UL 1449, listed and labeled for intended use by an NRTL acceptable to authorities having jurisdiction.
   2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.

B. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

C. Interface with DDC System for HVAC: Provide factory-installed hardware and software to enable the DDC system for HVAC to monitor, display, and record data for use in processing reports.
   1. ASHRAE 135 (BACnet), LonTalk, Modbus and Industry-accepted, open-protocol communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely monitor meter information from a DDC system for HVAC workstation. Control features and monitoring points displayed locally at metering panel shall be available through the DDC system for HVAC.

D. Backup Power Source:
   1. Electrical power distribution equipment served by a backup power source for controls shall have associated power monitoring and control system products that monitor and control such systems and equipment also served from a backup power source.
2.3 METERS AND CURRENT TRANSFORMERS

A. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1.
   1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
   2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.

B. Environment: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   1. Indoor installation in nontemperature-controlled spaces that have environmental controls to maintain ambient conditions of minus 13 to 158 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
   2. Comply with IEC 60529 degree of protection code of IP51 for the front of the meter, and code of IP30 for the body.

C. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

D. Accuracy:
   1. Comply with ANSI C12.20, Class 0.5.
   2. Neutral Current Measurement: Not more than 0.65 percent.
   3. Power: 0.6 percent.
   4. Power Factor: 0.5 percent.
   5. Active Energy: 0.6 percent.
   6. Reactive Energy: 2.5 percent.
   7. Frequency: 0.05 percent.
   8. THD: 1.0 percent.

E. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   2. Advanced single point metering devices: Leviton Energy Monitoring HUB + (EMH+), 3500, 4000 and 4100 Series
   4. Leviton solid or split core current transformers with full scale output of 0.1A or 0.333v
   5. Leviton Rogowski coil current transformers.
   6. Solid Core current transformers available for 100-400A and split core current transformers available from 100-5,000A.
   7. Current transformer secondary conductors can be extended:
      a. 500’ for 0.1A CT’s
      b. 300’ for 0.333V CT’s
      c. 20’ for Rogowski Coil CT’s

2.4 SYSTEM DESCRIPTION – SINGLE POINT METERING DEVICES

A. Provide single point metering devices capable of metering 1PH/2W, 2PH/3W, 3PH/3W, and/or 3PH/4W loads.

B. Meters must be capable of directly metering North American 120/208,277/480V.

C. Metering units must be capable of metering loads between 100A and 5000A. Provide meters as indicated on construction drawings.
D. Must meet all ISO 9001 standards for quality control where all meters test to a minimum of +/- 0.5% accuracy.

E. The system shall be as described below:
1. To consist of electronic meters with embedded communications capability, and solid or split-core current transformer technology. The current transformers shall have a full scale output of 0.1A or .333v and secondary voltage clamps for safety purposes.
2. Meters to be used for Energy Monitoring applications.
3. The meters will be capable of remote communication from each metering device.
4. Standard meters shall have isolated pulse output with output ranges from 10Wh to 1kWh.

E. Advanced meters shall transmit data via one of the following communication protocols:
   a. Isolated Pulse Output
   b. Modbus TCP/IP
   c. BACNet IP
   d. Modbus RTU
   e. BACNet MS/TP
5. Backup power provided by on-board battery maintains the real time clock through power loss (Advanced Meters Only). Energy data is stored in non-volatile memory to maintain value through power loss. Device is capable of holding 65 days of historical data in default settings (Advanced Meters Only).
6. Failure of the building electrical normal power system shall not result in loss of data and will not require manual restarting of the metering system.

F. The electronic energy monitoring system shall be fully automated microprocessor-based electrical energy measurement system for Measurement and Verification. The system shall incorporate complete metering, communications, reporting functions; energy monitoring and threshold limit capabilities.

2.5 SYSTEM MEASUREMENTS – SINGLE POINT METERING DEVICES

A. Meters to be complete with a Liquid Crystal Display (LCD) to access all energy measurements and phase diagnostics when needed.

B. Standard Meter Energy Parameters:
   1. kWh real consumption
   2. kW peak resettable kW peak

C. Advanced Meter Energy Parameters:
   1. Bi-directional Energy Measurements
   2. kWh real consumption
   3. kW peak resettable kW peak
   4. kW instantaneous consumption
   5. kVAh apparent energy consumption
   6. kVA total apparent power
   7. kVARh reactive consumption
   8. kVAR total reactive power
   9. PF power Factor Total
   10. Maximum kW peak demand with time and date stamp
11. **Line Frequency Hz**

D. **Advanced Meter Phase Diagnostics:** Parameters to be displayed for each individual phase of each metered load:

1. **Voltage** Phase to neutral or phase to phase
2. **Amps** Instantaneous amperage for each phase
3. **kW** Instantaneous real energy
4. **PF** Power factor
5. **kVA** Instantaneous apparent energy
6. **KVAR** Instantaneous reactive energy

2.6 **SYSTEM DESCRIPTION – MULTIPoint METERING DEVICES**

A. The system shall be as described below:

1. To consist of electronic multiple point meters with embedded communications capability, and solid or split-core current transformer technology. The current transformers shall have a full scale output of 0.1A outputs and secondary voltage clamps for safety purposes.
2. Meters to be used for Energy Monitoring and Tenant Billing applications
3. The meters will be capable of remote communication from each metering device. Each device shall have IP sockets and RS-485 terminals to accommodate data transmission via Modbus TCP/IP, BACNet IP, Modbus RTU and standard Ethernet. Data shall be transmitted by one or a combination of the following:
   a. Standard Ethernet interface
   b. Ethernet connection to PC or laptop via crossover cable.
   c. RS-485 Network-Modbus RTU
4. Systems to have backup storage power to key components so no data is lost during power outages. Device must be capable of holding 2 years of interval data for a 20 year period. The system shall continue to function after resumption of power.
5. Failure of the building electrical normal power system shall not result in loss of data and will not require manual restarting of the metering system

B. The electronic energy monitoring system shall be fully automated microprocessor-based electrical energy measurement system for Measurement and Verification and Tenant Billing purposes. The system shall incorporate the following:

1. Complete metering
2. Communications
3. Reporting functions
4. Energy monitoring
5. Threshold limits capabilities.

C. Meters must be capable of directly metering on board, North American 120/208 and 277/480V.

D. Meters must be capable of metering 480v Delta and 347/600v using PT’s.

E. Metering Units must have the capability of a Wiring Harness, single incoming cable containing 25 pairs of 22 AWG wire with associated current transformers (CT’s) or optional Terminal Strips, screw terminal connections for CT’s.

F. Must meet all ISO 9001 standards for quality control where all meters test to a minimum of +/- 0.5% accuracy.

G. Metering unit(s) must be configurable to meter 24 single-pole circuits, 12 two-pole circuits, or 8 three-pole circuits
2.7 SYSTEM MEASUREMENTS – MULTIPoint METERING DEVICES

A. Meters to be complete with a Liquid Crystal Display (LCD) to access energy measurements and phase diagnostics when needed

B. Energy Parameters:
   1. kWh  real consumption
   2. kW  instantaneous consumption
   3. kVAh  apparent consumption
   4. kVA  apparent power
   5. kVARh  reactive consumption
   6. kVAR  reactive power

C. Phase Diagnostics: Parameters to be displayed for each individual phase of each metered load:
   1. Voltage  Phase to neutral or phase to phase
   2. Amps  Instantaneous amperage for each phase
   3. kW  Instantaneous real energy
   4. PF  Power factor
   5. PA  Phase angle
   6. kVA  Instantaneous apparent energy
   7. KVAR  Instantaneous reactive energy

2.8 METER DATA COLLECTION AND COMMUNICATION

A. Data acquisition server: Leviton Energy Monitoring Hub and Hub Lite

B. Pulse data collection: Leviton High Density Pulse Module

C. Wireless data transmission: Leviton Modhopper

2.9 SYSTEM DESCRIPTION METER COMMUNICATIONS AND DATA COLLECTION

A. The system shall be as described below:
   1. To consist of energy management hubs, pulse modules, wireless communication devices, and software used to transmit, collect, and display data provided by sub-metering equipment used to capture measurements from utilities that include, but are not limited to, electrical, gas, water, and steam.
   2. System to allow all data collected to be connected to IP based applications including Third Party Billing Companies/Software, Enterprise Energy Management Software, Demand Response, and Smart Grid Collection for use in power Measurement and tenant billing.
   3. Data collection system shall be all non-proprietary and compatible with industry standard M&V software applications. Open protocols such as Modbus, pulse outputs, analog, resistive inputs, etc. shall be utilized. No proprietary or manufacturer specific protocols between meter and data collectors shall be accepted.

2.10 PRODUCT REQUIREMENTS - DATA ACQUISITION SERVER

A. Provide data acquisition servers that measure and verify data from electrical meters and environmental sensors.
B. Server shall comply with the following codes and standards:
1. FCC CFR 47 Part 15, Class A
2. EN 610000
3. EN 61326
4. CE

C. Server shall be equipped with an ARMg embedded CPU, an ARM7 I/O co-processor, 32MB of onboard RAM, 16MB of NOR flash memory, and a USB expansion port.

D. Server shall operate under the following conditions:
1. 32°F to 122°F (0°C to 50°C), 0-90% RH, non-condensing
2. 41°F to 104°F (5°C to 40°C), 0-90% RH, non-condensing

E. Server shall have the capability to collect and log information at intervals from one (1) to sixty (60) minutes.

F. Server shall timestamp all acquired data and store it in a non-volatile memory.

G. Server shall use modem and/or Ethernet connections for internet access allowing either static IP (internet protocol) or DHCP (Dynamic Host Control Protocol) addressing.

H. Server shall communicate with metering data points via wired or wireless connections over the following protocols:
   1. Wired communications:
      a. Pulse
      b. Ethernet-Modbus TCP/IP
      c. RS-485-Modbus RTU
         1) Modbus devices to be connected via Belden 1120A or equivalent 18g twisted shielded pair.
   2. Wireless Communications:
      a. Wireless Modbus

I. Server shall communicate with external devices via -wired or wireless connections over the following protocols:
   1. Wired communications:
      a. Ethernet LAN (Local Area Network) or WAN (Wide Area Network)
         1) TCP/IP
         2) PPP
         3) HTTP/HTML
         4) FTP
         5) NTP
         6) XML
         7) SNMP
         8) BACnet-Optional Downloaded Module
   2. Wireless Communications:
      a. GSM (Global System for Mobile Communications)
      b. GPRS (General Packet Radio Service)
      c. PSTN (Public Switched Telephone Network)

J. Server shall upload data at user selectable scheduled intervals via HTTP or FTP and download data in XML or custom formats.

K. Server shall generate alarms for data points including SNMP (Simple Network Management Protocol) traps.
L. Server shall have the following input and output connections:

1. Input:
   a. RS485 Modbus serial input capable of supporting 32 external devices. Input to be expandable at owner's option.
   b. Eight (8) Flex I/O inputs configurable for the following modes:
      1) 0-10VDC
      2) 4-20mA
      3) Resistive
      4) Standard KYZ pulse modes for A or C dry contact relay outputs
      5) Status

2. Output:
   a. Two (2) opto-FET dry contact relays rated at 30VDC and 150mA maximum

2.11 PRODUCT REQUIREMENTS – HIGH DENSITY PULSE MODULES

A. Provide high density pulse module for collection and distribution of pulse output data generated by electric.

B. Module shall have on-board, adjustable Modbus addressing via dip switches with addresses from 1-128.

C. Module shall comply with the following codes and standards:

D. Module shall be equipped with an ARM7 I/O processor with field-upgradable firmware.

E. Module shall communicate over a Modbus / RTU RS-485, two wire network with the following network speeds
   1. 19200 Baud
   2. 9600 Baud

F. Module shall operate under the following conditions
   1. -22°F to 158°F (-30°C to 70°C), 0-90% RH, non-condensing

G. Module shall have a 32-bit pulse counter which rolls over at 4.295 billion pulses per channel and store pulse data in a non-volatile memory. Pulse rate shall be user selectable.

H. Module shall have the following input and output connections
   1. Input
      a. Non isolated pulse and power inputs
      b. Modbus RS485 connection
      c. Twenty-three (23) independent pulse count inputs designed for use with dry contact outputs. The pulse rate shall be user selectable between the following:
         1) 10Hz: Minimum pulse width to be 50ms
         2) 50Hz: Minimum pulse width to be 10ms
         3) 100Hz
2.12 PRODUCT REQUIREMENTS – WIRELESS TRANSCEIVER

A. Provide OPTIONAL wireless transceiver for collection and distribution of pulse outputs generated by electrical meters, other energy and water meters and environmental sensors.

B. Transceiver shall comply with the following codes and standards:
   2. FCC ID to be OUR-9XTREAM

C. Transceiver shall be equipped with a 60 MHz ARM7 embedded CPU.

D. Transceiver firmware to be field upgradable.

E. Transceiver shall communicate over a self-healing, self-optimizing wireless mesh network. Network shall utilize frequency hopping, spread-spectrum radio transmission and reception over 900MHz band.

F. Transceiver shall have a range of 3000 feet indoors and 14 miles outdoor line of sight.

G. Transceiver broadcast power shall be 1 watt.

H. Transceiver shall operate under the following conditions
   1. 32°F to 122°F (0°C to 50°C), 0-90% RH, non-condensing
   2. 1.24 miles (2000m) maximum altitude, degree 2 pollution

I. Transceiver shall have a pulse counter with pulse data stored in a non-volatile memory.

J. Transceiver shall have the following input and output connections. Modbus addresses to be adjustable via DIP switches with addresses between 1 and 247.
   1. Input
      a. Two (2) Pulse inputs with user selectable pulse rates of 10, 50, 100, or 250 Hz.
      b. Modbus RS485 input
         1) Connect a maximum of 32 Modbus devices to transceiver input
   2. Output
      a. Modbus RS485 output
         1) Outputs to be user selectable between 100 Ohms and 2.5 kOhms.
      b. Two (2) opto-FET dry contact relays rated at 30VDC, 150mA max.

2.13 CLOUD BASED ENERGY INFORMATION SOFTWARE

A. Software package shall consist of one or more of the following modules:
   1. Basic Building Management Software BMO 3.0-Base Module

2.14 PRODUCT REQUIREMENTS-BASIC SOFTWARE-BMO 3.0 BASE MODULE

A. BMO 3.0 Base Module is a basic energy information platform that allows for basic reporting of limited graphing of energy information collected from energy and water meters and environmental sensors.

B. Provide a web hosted software platform which is fully functional without software other than standard web browsers including, but not limited to, Microsoft Internet Explorer, Google Chrome and Firefox Mozilla.
1. Software shall support multiple Leviton Energy Monitoring HUBs.

C. Software shall be used for the collection, analysis, and reporting of energy data from sub-metering equipment used to capture energy usage measurements that include, but are not limited to, electrical.

D. Software shall collect and report data in intervals 15 minute intervals by default.

E. Software shall produce configurable reports and display data for all engineering units available from the meters incorporated in to the system; kWh, kW.

F. Software will allow for graphical representation of up to 4 different metering points compared to each other on the graphical output.

G. Software shall allow for exportable tabular data in all report options; excel, .csv, etc.

H. Software shall allow for graphical representations of data in 15 minute intervals or other intervals as determined by the end user.

I. Software will allow for basic energy consumption and cost reporting.

J. Software shall allow for a Date Picking capability to allow for reports to be selected from the following time options:
   1. Last Hour, 8Hrs, Today, Yesterday, 7 days, Week, 30 days, Month, Last Month, Last 12 Months, This Year, Last Year
   2. User Defined Custom Period including date and time range as narrow as a single 15 minute interval

K. Report Header will display the range of total available data for the meter assigned to the report

L. Software will allow for the creation of user defined alarms for low and high readings for energy metrics reported on meters within the system.

2.15 PRODUCT REQUIREMENTS – EEM SOFTWARE-BMO 3.0 EXECUTIVE REPORTING MODULE

A. Description: BMO 3.0 Executive Reporting Module is an Enterprise Energy Management software platform designed to assist energy and facility managers in the conduct of daily energy management reporting and analysis functions. It is designed for portfolio level use incorporating a wide range of graphical interfaces and an executive dashboard for high level energy information.

B. Provide a web hosted software platform which is fully functional without software other than standard web browsers including, but not limited to, Microsoft Internet Explorer, Google Chrome and Firefox Mozilla

C. Software shall support a minimum of 10 separate facilities with 50 meters per facility; additional facilities/meters added as user requires

D. Software shall allow for unique facility information to be entered on Building Set Up Page to include:
   1. Facility Address Information
   2. Facility Square Footage
   3. Utility Cost Information
E. Software shall be used for the collection, analysis, and reporting of energy data from sub-metering equipment used to capture energy usage measurements that include, but are not limited to, electrical, gas, water, steam & BTU values.

F. Software shall collect and report data in intervals 15 minute intervals by default; other user defined intervals available.

G. Software shall produce configurable reports and display data for all engineering units available from the meters incorporated into the system; kWh, kW, gallons, BTU.hr, etc.

H. Software shall allow for exportable tabular data in all report options; excel, .csv, etc.

I. Software shall allow for a wide variety of graphical representations of data in the following options:
   1. 2 Dimensional Charts
      a. Area Charts
      b. Vertical Bar Charts
      c. Horizontal Bar Charts
      d. Pie Charts
      e. Donut Charts
      f. Smooth Area Charts
      g. Smooth Line Charts
      h. Scatter Charts
   2. 3 Dimensional Charts
      a. Vertical Bar Charts
      b. Horizontal Bar Charts
      c. Pie Charts
      d. Donut Charts

J. Software shall allow for graphical data to be displayed in the following time interval options:
   1. 15 minute
   2. One day
   3. One week
   4. One month
   5. One year

K. Software shall allow for a Date Picking capability to allow for reports to be selected from the following time options:
   1. Last Hour, 8Hrs, Today, Yesterday, 7 days, Week, 30 days, Month, Last Month, Last 12 Months, This Year, Last Year
   2. User Defined Custom Period including date and time range as narrow as a single 15 minute interval

L. Report Header will display the range of total available date for the meter or virtual meter assigned to the report

M. Software shall organize all user defined and pre-configured reports to be cataloged on a building specific dashboard including the following basic information:
   1. Street Map pinpointing the buildings geographic location
   2. Local current weather conditions displayed
   3. Building Performance Goal Odometers if configured

N. Software shall allow for the construction of Virtual Meters with the following parameters:
   1. Any number of like kind data points (kWh + kWh, etc)
   2. Combinations of data points from any HUB found in the software license
3. Combinations of virtual meters to create an additional virtual meter.
4. Virtual meter point data begins on the date and time the VM is created.

O. Software shall allow the creation of energy information alerts with the following parameters:
1. Alerts shall be either consumption or demand based
2. Alerts shall be configured to trip based on a fixed base point value with the following conditions:
   a. Less Than (<)
   b. Less Than or Equal to (<, =)
   c. Equal to (=)
   d. Greater Than or Equal to (> ,=)
   e. Greater Than (>)
3. Alerts will be configured to allow communications via the following methods:
   a. Text
   b. Email
   c. Mobile APP (Must have downloaded and activated BMO 3.0 Mobile APP)
   d. Option for continuous notification or single notification
4. Software shall allow for the creation of a Base Case Analysis for energy demand, consumption or cost
5. Base Case can be configured from any physical meter or virtual meter
6. Base Case date range/period is user selectable
7. Base Case Type can be selected from the following types:
   a. Cost
   b. Cost/SqFt
   c. Demand (Average)
   d. Demand(Peak)
   e. Usage-Consumption
   f. Usage-Consumption/Sqft
8. Base Case can be compared to any other period for the same meter or virtual meter
9. Base Case Comparison to be an option for display on the Executive Dashboard
10. Base Case Comparison data to be incorporated into Building Goal calculations

P. Software will allow for creation of specific Building Goals:
1. Building Goals must be specifically targeted against Base Case Analysis
2. Goal creation must allow for a buffer zone around the goal to be determined by user +/- 5%, etc
3. Building Goals must be displayed on specific building dashboard using an odometer type display.
4. Building Goals will be created for any values found in the Base Case Analysis
   a. Energy Cost
   b. Energy Cost/SqFt
   c. Energy Demand-Average
   d. Energy Demand-Peak
   e. Energy Consumption
   f. Energy Consumption/SqFt
5. Building Goal information will be capable of being displayed on the higher level executive dashboard

Q. Software will allow the creation of a configurable Executive Dashboard. Dashboard will be configurable by end user.
1. Dashboard will offer multiple layout schemes to offer the end user maximum impact of the displayed data
2. Dashboard will regularly refresh data every 15 minutes or as directed by the end user
3. Dashboard will allow for the following items to be displayed:
   a. Reports-Building or Portfolio Level-Graphical or Badge type
b. Carbon Footprint
c. Comparison Report
d. Building Goals
e. Base Case Comparisons
f. Street Map
g. Current/Future Weather data
h. Photo/Picture
i. Time Clock (Time Zone adjustable)

4. Dashboard will be shareable with other users via email.
5. Dashboard will be adjustable for use with multiple screen sizes and types.
6. BMO 3.0 Base module functionality will be enabled in conjunction with this module.

2.16 PRODUCT REQUIREMENTS – CODE COMPLIANCE MODULE - BMO 3.0

A. Description-BMO 3.0 Code Compliance Module is a cloud based software platform that is
designed to allow commercial building/facility operators to meet minimum requirements found
in existing and emerging State and Municipal energy codes related to energy metering, data
acquisition & storage and reporting.

B. Provide a web hosted software platform which is fully functional without software other than
standard web browsers including, but not limited to, Microsoft Internet Explorer, Google
Chrome and Firefox Mozilla

C. Software shall be used for the collection, analysis, and reporting of energy data from sub-
metering equipment used to capture energy usage measurements that include, but are not
limited to, electrical, gas, water, steam & BTU values for whole Building Energy Sources and
End User Energy categories

D. Software shall collect and report data in intervals 15 minute intervals by default; other user
defined intervals available.

E. Software shall produce configurable reports and display data for all engineering units available
from the meters incorporated in to the system; kWh, kW, gallons, BTU.hr, etc.

F. Software shall allow for a Date Picking capability to allow for reports to be selected from the
following time options:
   1. Last Hour, 8Hrs, Today, Yesterday, 7 days, Week, 30 days, Month, Last Month, Last 12
      Months, This Year, Last Year
   2. Defined Custom Period including date and time range as narrow as a single 15 minute
      interval
   3. Report Header will display the range of total available date for the meter or virtual meter
      assigned to the report
   4. Software will allow for the creation of alarms for low and high readings for energy metrics
      reported on incorporated meters.

G. Software shall allow for the construction of Virtual Meters with the following parameters:
   1. Any number of like kind data points (kWh + kWh, etc)
   2. Combinations of data points from any HUB found in the software license
   3. Combinations of virtual meters to create an additional virtual meter.
   4. Virtual meter point data begins on the date and time the VM is created.

H. Software shall allow for exportable tabular data in all report options; excel, .csv, etc.
I. Software shall allow for graphical representations of data in 15 minute intervals or other intervals as determined by the end user.

J. Software will allow for basic energy consumption, demand and cost reporting.

K. Report Header will display the range of total available date for the meter or virtual meter assigned to the report.

L. Software will allow for the creation of alarms for low and high readings for energy metrics reported on incorporated meters.

M. BMO 3.0 Base Module functionality will be enabled with this software module.

2.17 RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and CEC 70 Class 1 remote-control and signaling circuits.

B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for control wiring, RS-232 cable, and CEC 70 Class 2 remote-control and signaling circuits.

2.18 WIRES AND CABLES

A. Electrical Power Wiring: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
   1. Copper conductors are Type THHN/THWN-2.

B. RS-232 Cable:
   1. PVC-Jacketed, RS-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; PVC jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
      a. Type CM.
      b. Flame Resistance: UL 1581, vertical tray.
   2. Plenum-Type, RS-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
      a. Type CMP.

2.19 SURGE PROTECTION DEVICES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Leviton Manufacturing Co., Inc. or comparable product by one of the following:
   1. Eaton.
   2. GE Zenith Controls.
   3. Schneider Electric USA, Inc.

B. SPDs: Comply with UL 1449, Type 1 and Type 2.
1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual metal-oxide varistors in a given mode.

D. Comply with UL 1283.

E. Protection modes and UL 1449 SPD for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
   1. L-N: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
   2. L-G: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
   3. N-G: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
   4. L-L: 2000 V for 480Y/277 V 1200 V for 208Y/120 V.

F. Protection modes and UL 1449 SPD for 240/120-V, single-phase, three-wire circuits shall not exceed the following:
   1. L-N: 700 V.
   2. L-G: 700 V.
   3. N-G: 700 V.
   4. L-L: 1200 V.

G. SCCR: Equal or exceed 100 kA.

H. Nominal Rating: 20 and 10 kA.

I. Indoor Enclosures: NEMA 250, Type 1.

J. Outdoor Enclosures: NEMA 250, Type 3R.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 POWER MONITORING AND CONTROL SYSTEM INSTALLATION

A. Comply with NECA 1.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Wiring and Cabling Installation:
   1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.

E. Raceways Installation:
   1. Comply with Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and CEC 70 Class 1 remote-control and signaling circuits.
   2. Comply with Section 270528 "Communications Building Pathways" for control wiring, RS-232 cable, and CEC 70 Class 2 remote-control and signaling circuits.

F. Identification Installation:
   1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
   2. Comply with Section 271513 "Communications Horizontal Twisted Pair Cabling" for identification products and cable management system requirements for twisted pair cable, RS-485 cable, low-voltage control cable, and RS-232 cable.
   3. Comply with Section 271323 "Communications Backbone ISP Optical Fiber Cabling" and Section 271324 "Communications Backbone OSP Optical Fiber Cabling" for identification products and cable management system requirements for optical-fiber cable.

3.3 WORKSTATION INSTALLATION

A. Desktop Workstations Installation:
   1. Install workstation(s) at location(s) directed by Owner.
   2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single, duplex electrical power receptacle.
   3. Install software on workstation(s) and verify that software functions properly.
   4. Develop Project-specific graphics, trends, reports, logs, and historical database.
   5. Power workstation through a UPS unit. Locate UPS adjacent to workstation.

B. Portable Workstations Installation:
   1. Turn over portable workstations to Owner at Substantial Completion.
   2. Install software on workstation(s) and verify that software functions properly.

C. Graphics Application:
   1. Use system schematics indicated as starting point to create graphics.
   2. Develop Project-specific library of symbols for representing system equipment and products.
   3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
   4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.
   5. Seek Owner input in graphics development once using graphics software.
   6. Final editing shall be done on-site with Owner's review and feedback.
   7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy to include in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of the system operation and maintenance manual.

3.4 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

3.5 GROUNDING

A. For data communication wiring, comply with NECA/BICSI 568.

B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   2. Visually inspect balanced twisted pair cabling and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA-568-C.1.
   3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   4. Test balanced twisted pair cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
      a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
      b. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.
   5. Optical-Fiber Cable Tests:
      a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
      b. Link End-to-End Attenuation Tests:
         1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to IEC 61280-4-1.
         2) Attenuation test results for links shall be less than 2.0 dB.
   
a. Test Analog Signals:
   1) Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
   2) Check analog current signals using a precision current meter at zero, 50, and 100 percent.
   3) Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

b. Test Digital Signals:
   1) Check digital signals using a jumper wire.
   2) Check digital signals using an ohmmeter to test for contact making or breaking.

c. I/O Control Loop Tests:
   1) Test every I/O point to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
   2) Test every I/O point throughout its full operating range.
   3) Test every control loop to verify that operation is stable and accurate.
   4) Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop’s precision and stability via trend logs.
   5) Test and adjust every control loop for proper operation according to sequence of operation.
   6) Test software and hardware interlocks for proper operation.
   7) Operate each analog point at the following:
      a) Upper quarter of range.
      b) Lower quarter of range.
      c) At midpoint of range.
   8) Exercise each binary point.
   9) For every I/O point in the system, read and record each value at workstation, at controller, and at field instrument simultaneously. Value displayed at workstation and at field instrument shall match.
   10) Prepare and submit a report documenting results for each I/O point in the system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

D. Wiring and cabling will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 FINAL REVIEW

A. Submit written request to Construction Manager when the power monitoring and control system is ready for final review. Written request shall state the following:
   1. The system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
   2. The system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
3. The system monitoring and control of electrical distribution systems results in operation according to sequences of operation indicated.
4. The system is complete and ready for final review.

B. Review by Architect will be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Final review shall include a demonstration to parties participating in final review.

3.8 MAINTENANCE SERVICE

A. Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of defective components, cleaning, and adjusting as required for proper system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.9 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
   1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the power monitoring and control system.

B. Extent of Training:
   1. Base extent of training on scope and complexity of power monitoring and control system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
   2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
   3. Minimum Training Requirements:
      a. Provide no fewer than two days of training total.
      b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
      c. Total days of training shall be broken into not more than two separate training classes.
      d. Each training class shall be no fewer than one consecutive day(s).
C. Attendee Training Manuals:
   1. Provide each attendee with a color hard copy of all training materials and visual presentations.
   2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
   3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

D. Instructor Requirements:
   1. One or multiple qualified instructors, as required, to provide training.
   2. Instructors shall have no fewer than five years of providing instructional training on no fewer than five past projects with similar electrical monitoring and control system scope and complexity.

E. Training Outline: Submit training outline for Owner review at least 10 business days before scheduling training. Outline shall include a detailed agenda for each training day that is broken down into each training session that day, training objectives for each training session, and synopses for each lesson planned.

F. On-Site Training:
   1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
   2. Instructor shall provide training materials, projector, and other audiovisual equipment used in training.
   3. Provide as much of training located on-site as deemed feasible and practical by Owner.
   4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
   5. The workstation provided with the system shall be used in training. If workstation is not indicated, provide a temporary workstation to convey training content.

G. Off-Site Training:
   1. Provide conditioned training rooms and workspace with ample tables, chairs, power, and data connectivity for each attendee.
   2. Provide capability to remotely access to Project monitoring and control system for use in training.
   3. Provide a workstation for use by each attendee.

3.11 AT COMPLETION OF TRAINING:

A. Staff familiar with the system installed are capable of demonstrating operation of the system during final review.

B. Demonstration shall include, but not be limited to, the following:
   1. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
   2. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and workstations.
   3. Trends, summaries, logs, and reports set-up for Project.
4. Software’s ability to communicate with controllers, workstations, and uploading and downloading of control programs.
5. Software’s ability to edit control programs off-line.
6. Data entry to show Project-specific customizing capability including parameter changes.
7. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
8. Execution of digital and analog commands in graphic mode.
10. Online user guide and help functions.
11. For Each Meter:
   a. Memory: Programmed data, parameters, trend, and alarm history collected during normal operation is not lost during power failure.
   b. Operator Interface: Ability to connect directly to each meter with a portable workstation.
   c. Wiring Labels: Match control drawings.
   d. Network Communication: Ability to locate a meter on the network. Communication architecture matches Shop Drawings.
   e. Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.
12. For Each Workstation:
   a. I/O point lists agree with naming conventions.
   b. Graphics are complete.

END OF SECTION
SECTION 26 09 23.02 - LIGHTING CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Digital Lighting Controls
   2. Relay Panels
   3. Emergency Lighting Control (if applicable)

B. Related Sections:
   1. Section 26 27 26 "Wiring Devices* for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.
   2. Section 26 51 19 "LED Interior Lighting".
   3. Section 26 56 19 "LED Exterior Lighting".
   4. Section 26 63 15 "Planetarium Lighting Technology (PLTS)".

C. Control Intent – Control Intent includes, but is not limited to:
   1. Defaults and initial calibration settings for such items as time delay, sensitivity, fade rates, etc.
   2. Initial sensor and switching zones
   3. Initial time switch settings
   4. Task lighting and receptacle controls
   5. Emergency Lighting control (if applicable)

1.3 QUALITY ASSURANCE

A. Manufacturer: Minimum 10 years’ experience in manufacture of lighting controls.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Show installation details for the following:
      a. Occupancy sensors.
      b. Vacancy sensors.
      c. Daylighting sensors.
      d. Inwall controls.
   2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which equipment will be attached.
   3. Items penetrating finished ceiling, including the following:
      a. Luminaires.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
      f. Control modules.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's warranties.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On USB media and On manufacturer's website. Provide names, versions, and website addresses for locations of installed software.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Faulty operation of lighting control software.
      b. Faulty operation of lighting control devices.
2.1 SYSTEM DESCRIPTION AND OPERATION

A. The Lighting Control and Automation system as defined under this section covers the following equipment:

1. Digital Occupancy Sensors – Self-configuring, digitally addressable and calibrated occupancy sensors with LCD display and two-way active infrared (IR) communications.
2. Digital Switches – Self-configuring, digitally addressable pushbutton on/off, dimming, and scene switches with two-way active infrared (IR) communications.
3. Handheld remotes for personal control – One-button dimming, two-button on/off, or five-button scene remotes provide control using infrared communications. Remote may be configured in the field to control selected loads or scenes without special tools.
4. Digital Daylighting Sensors – Single-zone closed loop, multi-zone open loop and single-zone dual-loop daylighting sensors with two-way active infrared (IR) communications can provide switching, bi-level, tri-level or dimming control for daylight harvesting.
5. Digital Room Controllers – Self-configuring, digitally addressable one, two or three relay plenum-rated controllers for on/off control. Selected models include 0-10 volt or line voltage forward phase control dimming outputs and integral current monitoring capabilities.
7. Configuration Tools – Handheld remote for room configuration and relay panel programming provides two way infrared (IR) communications to digital devices and allows complete configuration and reconfiguration of the device / room from up to 30 feet away. Unit to have Organic LED display, simple pushbutton interface, and allow bi-directional communication of room variables and occupancy sensor settings. Computer software also customizes room settings.
8. Digital Lighting Management (DLM) local network – Free topology, plug-in wiring system (Cat 5e) for power and data to room devices.
9. Digital Lighting Management (DLM) segment network – Linear topology, BACnet MS/TP network (1.5 twisted pair, shielded,) to connect multiple DLM local networks for centralized control.
10. Network Bridge – provides BACnet MS/TP-compliant digital networked communication between rooms, panels and the Segment Manager or building automation system (BAS) and automatically creates BACnet objects representative of connected devices.
11. Segment Manager – provides web browser-based user interface for system control, scheduling, power monitoring, room device parameter administration and reporting.
12. Programming and Configuration software – Optional PC-native application capable of accessing DLM control parameters within a room, for the local network, via a USB adapter, or globally, for many segment networks simultaneously, via BACnet/IP communication.
13. LMCP Digital Lighting Management Relay Panel – provides up to 8, 24, or 48 mechanically latching relays. Relays include a manual override and a single push-on connector for easy installation or removal from the panel. Panel accepts program changes from handheld configuration tool for date and time, location, holidays, event scheduling, button binding and group programming. Provides
BACnet MS/TP-compliant digital networked communication between other lighting controls and/or building automation system (BAS).

14. Emergency Lighting Control Unit (ELCU) – allows a standard lighting control device to control emergency lighting in conjunction with normal lighting in any area within a building

2.2 LIGHTING CONTROL APPLICATIONS

A. Unless relevant provisions of the applicable local Energy Codes are more stringent, provide a minimum application of lighting controls as follows:

1. Space Control Requirements – Provide occupancy/vacancy sensors with Manual- or Partial-ON functionality in all spaces except toilet rooms, storerooms, library stacks, or other applications where hands-free operation is desirable and Automatic-ON occupancy sensors are more appropriate. Provide Manual-ON occupancy/vacancy sensors for any enclosed office, conference room, meeting room, open plan system and training room. For spaces with multiple occupants, or where line-of-sight may be obscured, provide ceiling- or corner-mounted sensors and Manual-ON switches.

2. Bi-Level Lighting – Provide multi-level controls in all spaces except toilet rooms, storerooms, library stacks, or applications where variable dimming is used.

3. Task Lighting / Plug Loads – Provide automatic shut off of non-essential plug loads and task lighting in all spaces except toilet rooms and storerooms. Provide Automatic-ON of plug loads whenever spaces are occupied. For spaces with multiple occupants a single shut off consistent with the overhead lighting may be used for the area.

4. Daylit Areas – Provide daylight-responsive automatic control in all spaces (conditioned or unconditioned) where daylight contribution is available as defined by relevant local building energy code:
   a. All luminaires within code-defined daylight zones shall be controlled separately from luminaires outside of daylit zones.
   b. Daytime setpoints for total ambient illumination (combined daylight and electric light) levels that initiate dimming shall be programmed in compliance with relevant local building energy codes.
   c. Multiple-leveled switched daylight harvesting controls may be utilized for areas marked on drawings.
   d. Provide smooth and continuous daylight dimming for areas marked on drawings. Daylighting control system may be designed to turn off electric lighting when daylight is at or above required lighting levels, only if system functions to turn lamps back on at dimmed level, rather than turning full-on prior to dimming.

5. Conference, meeting, training, auditoriums, and multipurpose rooms shall have controls that allow for independent control of each local control zone. Rooms larger than 300 square feet shall instead have at least four (4) pre-set lighting scenes unless otherwise specified. Occupancy / vacancy sensors shall be provided to extinguish all lighting in the space. Spaces with up to four moveable walls shall include controls that can be reconfigured when the room is partitioned.

2.3 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Watt Stopper; or a comparable product by one of the following:
1. Cooper Industries, Inc.
2. Lithonia Lighting; Acuity Brands Lighting, Inc.

2.4 DIGITAL LIGHTING CONTROLS

A. Furnish the Company’s system which accommodates the square-footage coverage requirements for each area controlled, utilizing room controllers, digital occupancy sensors, switches, daylighting sensors and accessories which suit the lighting and electrical system parameters.

2.5 DIGITAL WALL SWITCH OCCUPANCY SENSORS

A. Wallbox mounted passive infrared PIR or dual technology (passive infrared and ultrasonic) digital occupancy sensor with 1 or 2 switch buttons.

B. Digital Occupancy Sensors shall provide scrolling LCD display for digital calibration and electronic documentation. Features include the following:

1. Digital calibration and pushbutton configuration for the following variables:
   a. Sensitivity – 0-100% in 10% increments
   b. Time delay – 1-30 minutes in 1 minute increments
   c. Test mode – Five second time delay
   d. Detection technology – PIR, Dual Technology activation and/or re-activation.
   e. Walk-through mode
   f. Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the DLM local network.

2. Programmable control functionality including:
   a. Each sensor may be programmed to control specific loads within a local network.
   b. Sensor shall be capable of activating one of 16 user-definable lighting scenes.
   c. Adjustable retrigger time period for manual-on loads. Load will retrigger (turn on) automatically during the configurable period of time (default 10 seconds) after turning off.
   d. On dual technology sensors, independently configurable trigger modes are available for both Normal (NH) and After Hours (AH) time periods. The retrigger mode can be programmed to use the following technologies:
      1) Ultrasonic and Passive Infrared
      2) Ultrasonic or Passive Infrared
      3) Ultrasonic only
      4) Passive Infrared only
   3. Independently configurable sensitivity settings for passive infrared and ultrasonic technologies (on dual technology sensors) for both Normal (NH) and After Hour (AH) time periods.
   4. Two RJ-45 ports for connection to DLM local network.
   5. Two-way infrared (IR) transceiver to allow remote programming through handheld configuration tool and control by remote personal controls.
   6. Device Status LEDs including:
      a. PIR detection
      b. Ultrasonic detection
c. Configuration mode  
d. Load binding  
7. Assignment of occupancy sensor to a specific load within the room without wiring or special tools.  
8. Assignment of local buttons to specific loads within the room without wiring or special tools.  
10. All digital parameter data programmed into an individual wall switch sensor shall be retained in non-volatile FLASH memory within the wall switch sensor itself. Memory shall have an expected life of no less than 10 years.  

C. BACnet object information shall be available for the following objects:  
1. Detection state  
2. Occupancy sensor time delay  
3. Occupancy sensor sensitivity, PIR and Ultrasonic  
4. Button state  
5. Switch lock control  
6. Switch lock status  

D. Units shall not have any dip switches or potentiometers for field settings.  

E. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required.  

F. Two-button wall switch occupancy sensors, when connected to a single relay dimming room controller, shall operate in the following sequence as a factory default:  
1. Left button  
   a. Press and release - Turn load on  
   b. Press and hold - Raise dimming load  
2. Right button  
   a. Press and release - Turn load off  
   b. Press and hold - Lower dimming load  

G. Low voltage momentary pushbuttons shall include the following features:  
1. Load/Scene Status LED on each switch button with the following characteristics:  
   a. Bi-level LED  
   b. Dim locator level indicates power to switch  
   c. Bright status level indicates that load or scene is active  
2. The following button attributes may be changed or selected using a wireless configuration tool:  
   a. Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).  
   b. Individual button function may be configured to Toggle, On only or Off only.  
   c. Individual scenes may be locked to prevent unauthorized change.  
   d. Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.  
   e. Ramp rate may be adjusted for each dimmer switch.  
   f. Switch buttons may be bound to any load on a room controller and are not load type dependent; each button may be bound to multiple loads.
H. WattStopper part numbers: LMPW, LMDW. Available in white, light almond, ivory, grey, red and black; compatible with wall plates with decorator opening.

2.6 DIGITAL WALL OR CEILING MOUNTED OCCUPANCY SENSOR

A. Wall or ceiling mounted (to suit installation) passive infrared (PIR), ultrasonic or dual technology digital (passive infrared and ultrasonic) occupancy sensor.

B. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and electronic documentation. Features include the following:

1. Digital calibration and pushbutton configuration for the following variables:
   a. Sensitivity – 0-100% in 10% increments
   b. Time delay – 1-30 minutes in 1 minute increments
   c. Test mode – Five second time delay
   d. Detection technology – PIR, Ultrasonic or Dual Technology activation and/or re-activation.
   e. Walk-through mode
   f. Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the DLM local network.

2. Programmable control functionality including:
   a. Each sensor may be programmed to control specific loads within a local network.
   b. Sensor shall be capable of activating one of 16 user-definable lighting scenes.
   c. Adjustable retrigger time period for manual-on loads. Load will retrigger (turn on) automatically within a configurable period of time (default 10 seconds) after turning off.
   d. On dual technology sensors, independently configurable trigger modes are available for both Normal (NH) and After Hours (AH) time periods. The retrigger mode can be programmed to use the following technologies:
      1) Ultrasonic and Passive Infrared
      2) Ultrasonic or Passive Infrared
      3) Ultrasonic only
      4) Passive Infrared only
   e. One or two RJ-45 port(s) for connection to DLM local network.
   f. Two-way infrared (IR) transceiver to allow remote programming through handheld commissioning tool and control by remote personal controls.
   g. Device Status LEDs, which may be disabled for selected applications, including:
      a. PIR detection
      b. Ultrasonic detection
      c. Configuration mode
      d. Load binding

3. Independently configurable sensitivity settings for passive infrared and ultrasonic technologies (on dual technology sensors) for both Normal (NH) and After Hour (AH) time periods.

4. One or two RJ-45 port(s) for connection to DLM local network.

5. Two-way infrared (IR) transceiver to allow remote programming through handheld commissioning tool and control by remote personal controls.

6. Device Status LEDs, which may be disabled for selected applications, including:
   a. PIR detection
   b. Ultrasonic detection
   c. Configuration mode
   d. Load binding

7. Assignment of occupancy sensor to a specific load within the room without wiring or special tools.

9. All digital parameter data programmed into an individual occupancy sensor shall be retained in non-volatile FLASH memory within the sensor itself. Memory shall have an expected life of no less than 10 years.

C. BACnet object information shall be available for the following objects:
   1. Detection state
   2. Occupancy sensor time delay
   3. Occupancy sensor sensitivity, PIR and Ultrasonic

D. Units shall not have any dip switches or potentiometers for field settings.

E. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required.

F. WattStopper product numbers: LMPX, LMDX, LMPC, LMUC, LMDC

2.7 DIGITAL WALL SWITCHES

A. Low voltage momentary pushbutton switches in 1, 2, 3, 4, 5 and 8 button configuration. Wall switches shall include the following features:
   1. Two-way infrared (IR) transceiver for use with personal and configuration remote controls.
   2. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
   3. Configuration LED on each switch that blinks to indicate data transmission.
   4. Load/Scene Status LED on each switch button with the following characteristics:
      a. Bi-level LED
      b. Dim locator level indicates power to switch
      c. Bright status level indicates that load or scene is active
   5. Dimming switches shall include seven bi-level LEDs to indicate load levels using 14 steps.
   6. Programmable control functionality including:
      a. Button priority may be configured to any BACnet priority level, from 1-16, corresponding to networked operation allowing local actions to utilize life safety priority
      b. Scene patterns may be saved to any button other than dimming rockers. Once set, buttons may be digitally locked to prevent overwriting of the preset levels.
   7. All digital parameter data programmed into an individual wall switch shall be retained in non-volatile FLASH memory within the wall switch itself. Memory shall have an expected life of no less than 10 years.

B. BACnet object information shall be available for the following objects:
   1. Button state
   2. Switch lock control
   3. Switch lock status

C. Two RJ-45 ports for connection to DLM local network.
D. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration shall be required to achieve multi-way switching.

E. The following switch attributes may be changed or selected using a wireless configuration tool:
1. Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
2. Individual button function may be configured to Toggle, On only or Off only.
3. Individual scenes may be locked to prevent unauthorized change.
4. Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.
5. Ramp rate may be adjusted for each dimmer switch.
6. Switch buttons may be bound to any load on a room controller and are not load type dependant; each button may be bound to multiple loads.


2.8 HANDHELD REMOTE CONTROLS

A. Battery-operated handheld devices in 1, 2 and 5 button configurations for remote switching or dimming control. Remote controls shall include the following features:
1. Two-way infrared (IR) transceiver for line of sight communication with DLM local network within up to 30 feet.
2. LED on each button confirms button press.
3. Load buttons may be bound to any load on a room controller and are not load type dependant; each button may be bound to multiple loads.
4. Inactivity timeout to save battery life.

B. A wall mount holster and mounting hardware shall be included with each remote control

C. WattStopper part numbers: LMRH-101, LMRH-102, LMRH-105.

2.9 DIGITAL PARTITION CONTROLS

A. Partition controls shall enable manual or automatic coordination of lighting controls in flexible spaces with up to four moveable walls by reconfiguring the connected digital switches and occupancy sensors.

B. Four-button low voltage pushbutton switch for manual control.
1. Two-way infrared (IR) transceiver for use with configuration remote control.
2. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
3. Configuration LED on each switch that blinks to indicate data transmission.
4. Each button represents one wall; Green button LED indicates status.
5. Two RJ-45 ports for connection to DLM local network.
C. Contact closure interface for automatic control via input from limit switches on movable walls (by others).
   1. Operates on Class 2 power supplied by DLM local network.
   2. Includes 24VDC output and four input terminals for maintained third party contract closure inputs.
      a. Input max. sink/source current: 1-5mA
      b. Logic input signal voltage High: >18VDC
      c. Logic input signal voltage Low: <2VDC
   3. Four status LEDs under hinged cover indicate if walls are open or closed; supports LMPS-104 as remote status indicator.
   4. Two RJ-45 ports for connection to DLM local network.
   5. WattStopper part number: LMIO-102

2.10 DIGITAL DAYLIGHTING SENSORS

A. Digital daylighting sensors shall work with room controllers to provide automatic switching, bi-level, or tri-level or dimming daylight harvesting capabilities for any load type connected to a room controller. Daylighting sensors shall be interchangeable without the need for rewiring.
   1. Closed loop sensors measure the ambient light in the space and control a single lighting zone.
   2. Open loop sensors measure incoming daylight in the space and are capable of controlling up to three lighting zones.
   3. Dual loop sensors measure both ambient and incoming daylight in the space to ensure that proper light levels are maintained as changes to reflective materials are made in a single zone.

B. Digital daylighting sensors shall include the following features:
   1. The sensor’s internal photodiode shall only measure lightwaves within the visible spectrum. The photodiode’s spectral response curve shall closely match the entire photopic curve. The photodiode shall not measure energy in either the ultraviolet or infrared spectrums. The photocell shall have a sensitivity of less than 5% for any wavelengths less than 400 nanometers or greater than 700 nanometers.
   2. Sensor light level range shall be from 1-6,553 footcandles (fc).
   3. The capability of ON/OFF, bi-level or tri-level switching, or dimming, for each controlled zone, depending on the selection of room controller(s) and load binding to room controller(s).
   4. For switching daylight harvesting, the photosensor shall provide a field-selectable deadband, or a separation, between the “ON Setpoint” and the “OFF Setpoint” that will prevent the lights from cycling excessively after they turn off.
   5. For dimming daylight harvesting, the photosensor shall provide the option, when the daylight contribution is sufficient, of turning lights off or dimming lights to a field-selectable minimum level.
   6. Photosensors shall have a digital, independently configurable fade rate for both increasing and decreasing light level in units of percent per second.
   7. Photosensors shall provide adjustable cut-off time. Cut-off time is defined by the number of selected minutes the load is at the minimum output before the load turns off. Selectable range between 0-240 minutes including option to never cut-off.
   8. Optional wall switch override shall allow occupants to reduce lighting level to increase energy savings or, if permitted by system administrator, raise lighting levels for a selectable period of time or cycle of occupancy.
9. Integral infrared (IR) transceiver for configuration and/or commissioning with a handheld configuration tool, to transmit detected light level to wireless configuration tool, and for communication with personal remote controls.

10. Configuration LED status light on device that blinks to indicate data transmission.

11. Status LED indicates test mode, override mode and load binding.

12. Recessed switch on device to turn controlled load(s) ON and OFF.

13. BACnet object information shall be available for the following daylighting sensor objects, based on the specific photocell’s settings:
   a. Light level
   b. Day and night setpoints
   c. Off time delay
   d. On and off setpoints
   e. Up to three zone setpoints
   f. Operating mode – on/off, bi-level, tri-level or dimming

14. One RJ-45 port for connection to DLM local network.

15. A choice of accessories to accommodate multiple mounting methods and building materials. The photosensors may be mounted on a ceiling tile, skylight light well, suspended lighting fixture or backbox. Standard tube photosensors accommodate mounting materials from 0-0.62” thickness (LMLS-400, LMLS-500). Extended tube photosensors accommodate mounting materials from 0.62”-1.25” thickness (LMLS-400-L, LMLS-500-L). Mounting brackets are compatible with J boxes (LMLS-MB1) and wall mounting (LMLS-MB2). LMLS-600 photosensor to be mounted on included bracket below skylight well.

16. Any load or group of loads in the room can be assigned to a daylighting zone

17. Each load within a daylighting zone can be individually enabled or disabled for discrete control (load independence).

18. All digital parameter data programmed into a photosensor shall be retained in non-volatile FLASH memory within the photosensor itself. Memory shall have an expected life of no less than 10 years.

C. Closed loop digital photosensors shall include the following additional features:
   1. An internal photodiode that measures light in a 100-degree angle, cutting off the unwanted light from bright sources outside of this cone.
   2. Automatic self-calibration, initiated from the photosensor, a wireless configuration tool or a PC with appropriate software.
   3. Automatically establishes application-specific setpoints following self-calibration. For switching operation, an adequate deadband between the ON and OFF setpoints shall prevent the lights from cycling; for dimming operation a sliding setpoint control algorithm with separate Day and Night setpoints shall prevent abrupt ramping of loads.
   4. WattStopper Product Number: LMLS-400, LMLS-400-L.

D. Open loop digital photosensors shall include the following additional features:
   1. An internal photodiode that measures light in a 60-degree angle cutting off the unwanted light from the interior of the room.
   2. Automatically establishes application-specific setpoints following manual calibration using a wireless configuration tool or a PC with appropriate software. For switching operation, an adequate deadband between the ON and OFF setpoints for each zone shall prevent the lights from cycling; for dimming operation, a proportional control algorithm shall maintain the design lighting level in each zone.
   3. Each of the three discrete daylight zones can include any non overlapping group of loads in the room.
4. WattStopper Product Number: LMLS-500, LMLS-500-L.

E. Dual loop digital photosensors shall include the following additional features:

1. Close loop portion of dual loop device must have an internal photodiode that measures light in a 100 degree angle, cutting off the unwanted light from sources outside of this con
2. Open loop portion of dual loop device must have an internal photodiode that can measure light in a 60 degree angle, cutting off the unwanted light from the interior of the room.
3. Automatically establishes application-specific set-points following self-calibration. For switching operation, an adequate deadband between the ON and OFF setpoints shall prevent the lights from cycling; for dimming operation a sliding setpoint control algorithm with separate Day and Night setpoints shall prevent abrupt ramping of load.
4. Device must reference closed loop photosensor information as a base line reference. The device must be able to analyze the open loop photosensor information to determine if an adjustment in light levels is required.
5. Device must be able to automatically commission setpoints each night to provide adjustments to electrical lighting based on changes in overall lighting in the space due to changes in reflectance within the space or changes to daylight contribution based on seasonal changes.
6. Device must include extendable mounting arm to properly position sensor within a skylight well.
7. WattStopper product number LMLS-600

2.11 DIGITAL ROOM CONTROLLERS AND PLUG-LOAD CONTROLLERS

A. Digital controllers for lighting and plug loads automatically bind the room loads to the connected devices in the space without commissioning or the use of any tools. Room and plug load controllers shall be provided to match the room lighting and plug load control requirements. The controllers will be simple to install, and will not have dip switches or potentiometers, or require special configuration for standard Plug n’ Go applications. The control units will include the following features:

1. Automatic room configuration to the most energy-efficient sequence of operation based upon the devices in the room.
2. Simple replacement – Using the default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf.
3. Multiple room controllers connected together in a local network must automatically prioritize each room controller, without requiring any configuration or setup, so that loads are sequentially assigned using room controller device ID’s from highest to lowest.
4. Device Status LEDs to indicate:
   a. Data transmission
   b. Device has power
   c. Status for each load
   d. Configuration status
5. Quick installation features including:
   a. Standard junction box mounting
   b. Quick low voltage connections using standard RJ-45 patch cable
6. Based on individual configuration, each load shall be capable of the following behavior on power up following the loss of normal power:
a. Turn on to 100%
b. Remain off
c. Turn on to last level

7. Each load shall be configurable to operate in the following sequences based on occupancy:
   a. Auto-on/Auto-off (Follow on and off)
   b. Manual-on/Auto-off (Follow off only)

8. The polarity of each load output shall be reversible, via digital configuration, so that on is off and off is on.

9. BACnet object information shall be available for the following objects:
   a. Load status
   b. Electrical current
   c. Total watts per controller
   d. Schedule state – normal or after-hours
   e. Demand response control and cap level
   f. Room occupancy status
   g. Total room lighting and plug loads watts
   h. Total room watts/sq ft
   i. Force on/off all loads

10. UL 2043 plenum rated
11. Manual override and LED indication for each load
12. Dual voltage (120/277 VAC, 60 Hz), or 347 VAC, 60 Hz (selected models only).
    120/277 volt models rated for 20A total load, derating to 16A required for some dimmed loads (forward phase dimming); 347 volt models rated for 15A total load; plug load controllers carry application-specific UL 20 rating for receptacle control.
13. Zero cross circuitry for each load
14. All digital parameter data programmed into an individual room controller or plug load controller shall be retained in non-volatile FLASH memory within the controller itself. Memory shall have an expected life of no less than 10 years.

B. On/Off Room Controllers shall include:
   1. One or two relay configuration
   2. Efficient 150 mA switching power supply
   3. Three RJ-45 DLM local network ports with integral strain relief and dust cover
   4. WattStopper product numbers: LMRC-101, LMRC-102

C. On/Off/Dimming enhanced Room Controllers shall include:
   1. Real time current monitoring
   2. Multiple relay configurations
      a. One, two or three relays (LMRC-21x series)
      b. One or two relays (LMRC-22x series)
   3. Efficient 250 mA switching power supply
   4. Four RJ-45 DLM local network ports with integral strain relief and dust cover
   5. One dimming output per relay
      a. 0-10V Dimming - Where indicated, one 0-10 volt analog output per relay for control of compatible ballasts and LED drivers. The 0-10 volt output shall automatically open upon loss of power to the Room Controller to assure full light output from the controlled lighting. (LMRC-21x series)
      b. Line Voltage, Forward Phase Dimming - Where indicated, one forward phase control line voltage dimming output per relay for control of compatible
two-wire or three-wire ballasts, LED drivers, MLV, forward phase compatible ELV, neon/cold cathode and incandescent loads. (LMRC-22x series)

c. Each dimming output channel shall have an independently configurable minimum and maximum calibration trim level to set the dimming range to match the true dynamic range of the connected ballast or driver.
d. The LED level indicators on bound dimming switches shall utilize this new maximum and minimum trim.
e. Each dimming output channel shall have an independently configurable minimum and maximum trim level to set the dynamic range of the output within the new 0-100% dimming range defined by the minimum and maximum calibration trim.
f. Calibration and trim levels must be set per output channel.
g. Devices that set calibration or trim levels per controller are not acceptable.
h. All configuration shall be digital. Devices that set calibration or trim levels per output channel via trim pots or dip-switches are not acceptable.

6. Each load shall have an independently configurable preset on level for Normal Hours and After Hours events to allow different dimmed levels to be established at the start of both Normal Hours and After Hours events.

7. Fade rates for dimming loads shall be specific to bound switch buttons, and the load shall maintain a default value for any bound buttons that do not specify a unique value.

8. The following dimming attributes may be changed or selected using a wireless configuration tool:
   a. Establish preset level for each load from 0-100%
   b. Set high and low trim for each load
   c. Set lamp burn in time for each load up to 100 hours

9. Override button for each load provides the following functions:
   a. Press and release for on/off control
   b. Press and hold for dimming control

10. WattStopper product numbers: LMRC-211, LRMC-212, LRMC-213, LMRC-221, LMRC-222

D. Plug Load Room Controllers shall include:

1. One relay configuration with additional connection for unswitched load
2. Configurable additive time delay to extend plug load time delay beyond occupancy sensor time delay (e.g. a 10 minute additive delay in a space with a 20 minute occupancy sensor delay ensures that plug loads turn off 30 minutes after the space is vacated).
3. Factory default operation is Auto-on/Auto-off, based on occupancy
4. Real time current monitoring of both switched and un-switched load (LMPL-201 only)
5. Efficient switching power supply
   a. 150mA (LMPL-101)
   b. 250mA (LMPL-201)

6. RJ-45 DLM local network ports
   a. Three RJ-45 ports (LMPL-101)
   b. Four RJ-45 ports (LMPL-201)

2.12 DLM LOCAL NETWORK (ROOM NETWORK)

A. The DLM local network is a free topology lighting control physical connection and communication protocol designed to control a small area of a building.

B. Features of the DLM local network include:
   1. Plug n’ Go® automatic configuration and binding of occupancy sensors, switches and lighting loads to the most energy-efficient sequence of operation based upon the device attached.
   2. Simple replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
   3. Push n’ Learn® configuration to change the automatic configuration, including binding and load parameters without tools, using only the buttons on the digital devices in the local network.
   4. Two-way infrared communications for control by handheld remotes, and configuration by a handheld tool including adjusting load parameters, sensor configuration and binding, within a line of sight of up to 30 feet from a sensor, wall switch or IR receiver.

C. Digital room devices connect to the local network using pre-terminated Cat 5e cables with RJ-45 connectors, which provide both data and power to room devices. Systems that utilize RJ-45 patch cords but do not provide serial communication data from individual end devices are not acceptable.

D. If manufacturer’s pre-terminated Cat 5e cables are not used for the installation, the contractor is responsible for testing each cable following installation and supplying manufacturer with test results.

E. WattStopper Product Number: LMRJ-Series

2.13 DLM SEGMENT NETWORK (ROOM TO ROOM NETWORK)

A. The segment network shall be a linear topology, BACnet-based MS/TP subnet to connect DLM local networks (rooms) and LMCP relay panels for centralized control.
   1. Each connected DLM local network shall include a single network bridge (LMBC-300), and the network bridge is the only room-based device that is connected to the segment network.
   2. Network bridges, relay panels and segment managers shall include terminal blocks, with provisions for separate “in” and “out” terminations, for segment network connections.
   3. The segment network shall utilize 1.5 twisted pair, shielded, cable supplied by the lighting control manufacturer. The maximum cable run for each segment is 4,000 feet. Conductor-to-conductor capacitance of the twisted pair shall be less than 30 pf/ft and have a characteristic impedance of 120 Ohms.
   4. Network signal integrity requires that each conductor and ground wire be correctly terminated at every connected device.
   5. Substitution of manufacturer-supplied cable must be pre-approved: Manufacturer will not certify network reliability, and reserves the right to void warranty, if non-approved cable is installed, and if terminations are not completed according to manufacturer’s specific requirements.
   6. Segment networks shall be capable of connecting to BACnet-compliant BAS (provided by others) either directly, via MS/TP, or through NB-ROUTERS, via BACnet/IP or BACnet/Ethernet. Systems whose room-connected network...
infrastructure require gateway devices to provide BACnet data to a BAS are unacceptable.

B. WattStopper Product Number: LM-MSTP, LM-MSTP-DB

2.14 CONFIGURATION TOOLS

A. A wireless configuration tool facilitates optional customization of DLM local networks using two-way infrared communications, while PC software connects to each local network via a USB interface.

B. Features and functionality of the wireless configuration tool shall include but not be limited to:
   1. Two-way infrared (IR) communication with DLM IR-enabled devices within a range of approximately 30 feet.
   2. High visibility organic LED (OLED) display, pushbutton user interface and menu-driven operation.
   3. Must be able to read and modify parameters for room controllers, occupancy sensors, wall switches, daylighting sensors, network bridges and relay panels, and identify room devices by type and serial number.
   4. Save up to eight occupancy sensor setting profiles, and apply profiles to selected sensors.
   5. Temporarily adjust light level of any load(s) on the local network, and incorporate those levels in scene setting. Set room mode for testing of Normal Hours (NH) and After Hours (AH) parameter settings.
   6. Adjust or fine-tune daylighting settings established during auto-configuration, and input light level data to complete configuration of open loop daylighting controls.
   7. Set room mode for testing of Normal Hours (NH) and After Hours (AH) parameter settings.
   8. Verify status of building level network devices.

C. WattStopper Product Numbers: LMCT-100, LMCI-100/LMCS-100

2.15 NETWORK BRIDGE

A. The network bridge module connects a DLM local network to a BACnet-compliant segment network for communication between rooms, relay panels and a segment manager or BAS. Each local network shall include a network bridge component to provide a connection to the local network room devices. The network bridge shall use industry standard BACnet MS/TP network communication and an optically isolated EIA/TIA RS-485 transceiver.

   1. The network bridge shall be provided as a separate module connected on the local network through an available RJ-45 port.
   2. Provide Plug n’ Go operation to automatically discover room devices connected to the local network and make all device parameters visible to the segment manager via the segment network. No commissioning shall be required for set up of the network bridge on the local network.
   3. The network bridge shall automatically create standard BACnet objects for selected room device parameters to allow any BACnet-compliant BAS to include lighting control and power monitoring features as provided by the DLM room devices on each local network. BACnet objects will be created for the addition or replacement of any given in-room DLM device for the installed life of the system.
Products requiring that an application-specific point database be loaded to create or map BACnet objects are not acceptable. Systems not capable of providing BACnet data for control devices via a dedicated BACnet Device ID and physical MS/TP termination per room are not acceptable. Standard BACnet objects shall be provided as follows:

a. Read/write the normal or after hours schedule state for the room
b. Read the detection state of each occupancy sensor
c. Read the aggregate occupancy state of the room
d. Read/write the On/Off state of loads
e. Read/write the dimmed light level of loads
f. Read the button states of switches
g. Read total current in amps, and total power in watts through the room controller
h. Read/write occupancy sensor time delay, PIR sensitivity and ultrasonic sensitivity settings
i. Activate a preset scene for the room
j. Read/write daylight sensor fade time and day and night setpoints
k. Read the current light level, in footcandles, from interior and exterior photosensors and photocells
l. Set daylight sensor operating mode
m. Read/write wall switch lock status
n. Read watts per square foot for the entire controlled room
o. Write maximum light level per load for demand response mode
p. Read/write activation of demand response mode for the room
q. Activate/restore demand response mode for the room

B. WattStopper product numbers: LMBC-300

2.16 SEGMENT MANAGER

A. For networked applications, the Digital Lighting Management system shall include at least one segment manager to manage network communication. It shall be capable of serving up a graphical user interface via a standard web browser utilizing either unencrypted TCP/IP traffic via a configurable port (default is 80) or 256 bit AES encrypted SSL TCP/IP traffic via a configurable port (default is 443).

B. Each segment manager shall have integral support for at least three segment networks. Segment networks may alternately be connected to the segment manager via external routers and switches, using standard Ethernet structured wiring. Each router shall accommodate one segment network. Provide the quantity of routers and switches as shown on the plans.

C. Operational features of the Segment Manager shall include the following:

1. Connection to PC or LAN via standard Ethernet TCP/IP via standard Ethernet TCP/IP with the option to use SSL encrypted connections for all traffic.
2. Easy to learn and use graphical user interface, compatible with Internet Explorer 8, or equal browser. Shall not require installation of any lighting control software to an end-user PC. This issue needs confirmation with end user.
3. Log in security capable of restricting some users to view-only or other limited operations.
4. Automatic discovery of DLM devices and relay panels on the segment network(s). Commissioning beyond activation of the discovery function shall not be required
to provide communication, monitoring or control of all local networks and lighting control panels.

5. After discovery, all rooms and panels shall be presented in a standard navigation tree format. Selecting a device from the tree will allow the device settings and operational parameters to be viewed and changed by the user.

6. Ability to view and modify room device operational parameters. It shall be possible to set device parameters independently for normal hours and after hours operation including sensor time delays and sensitivities, and load response to sensor including Manual-On or Auto-On.

7. Ability to set up schedules for rooms and panels, view and override current status of panel channels and relays and assign relays to groups. Schedules shall automatically set controlled zones or areas to either a normal hours or after hours mode of operation. Support for a minimum of 100 unique schedules, each with up to four time events per day. Support for annual schedules, holiday schedules and unique date-bound schedules.

8. Ability to group rooms and loads for common control by schedules, switches or network commands.

9. Ability to monitor connected load current and display power consumption for areas equipped with room controllers incorporating the integral current monitoring feature.

10. Provide capabilities for integration with a BAS via BACnet protocol. At a minimum, the following points shall be available to the BAS via BACnet IP connection to the segment manager: room occupancy state; room schedule mode; room switch lock control; individual occupancy sensor state; room lighting power; room plug-load power; load ON/OFF state; load dimming level; panel channel schedule state; panel relay state; and Segment Manager Group schedule state control.

11. The Segment Manager shall allow access and control of the overall system database via Native Niagara AX FOX connectivity. Systems that must utilize a Tridium Niagara controller in addition to the programming, scheduling and configuration server are not acceptable.

D. Segment Manager shall support multiple DLM rooms as follows:

1. Support up to 120 network bridges and 900 digital in-room devices (LMSM-3E).
2. Support up to 300 network bridges and 2,200 digital in-room devices, connected via network routers and switches (LMSM-6E).


2.17 PROGRAMMING, CONFIGURATION AND DOCUMENTATION SOFTWARE

A. PC-native application for optional programming of detailed technician-level parameter information for all DLM products, including all parameters not accessible via BACnet and the handled IR configuration tool. Software must be capable of accessing room-level parameter information locally within the room when connected via the optional LMCI-100 USB programming adapter, or globally for many segment networks simultaneously utilizing standard BACnet/IP communication.

1. Additional parameters exposed through this method include but are not limited to:
   a. Occupancy sensor detection LED disable for performance and other aesthetic spaces where blinking LEDs present a distraction.
   b. Six occupancy sensor action behaviors for each controlled load, separately configurable for normal hours and after hours modes. Modes include: No Action, Follow Off Only, Follow On Only, Follow On and Off, Follow On Only...
with Override Time Delay, Follow Off Only with Blink Warn Grace Time, Follow On and Off with Blink Warn Grace Time.
c. Separate fade time adjustments per load for both normal and after hours from 0 - 4 hours.
d. Configurable occupancy sensor re-trigger grace period from 0 - 4 minutes separate for both normal hours and after hours.
e. Separate normal hours and after hours per-load button mode with modes including: Do nothing, on only, off only, on and off.
f. Load control polarity reversal so that on events turn loads off and vice versa.
g. Per-load DR (demand response) shed level in units of percent.
h. Load output pulse mode in increments of 1 second.
i. Fade trip point for each load for normal hours and after hours that establishes the dimmer command level at which a switched load closes its relay to allow for staggered On of switched loads in response to a dimmer.

2. Generation of reports at the whole file, partial file, or room level. Reports include but are not limited to:
   a. Device list report: All devices in a project listed by type.
   b. Load binding report: All load controller bindings showing interaction with sensors, switches, and daylighting.
   c. BACnet points report: Per room Device ID report of the valid BACnet points for a given site's BOM.
   d. Room summary report: Device manifest for each room, aggregated by common BOM, showing basic sequence of operations.
   e. Device parameter report: Per-room lists of all configured parameters accessible via hand held IR programmer for use with O&M documentation.
   f. Scene report: All project scene pattern values not left at defaults (i.e. 1 = all loads 100%, 2 = all loads 75%, 3 = all loads 50%, 4 = all loads 25%, 5-16 = same as scene 1).
   g. Occupancy sensor report: Basic settings including time delay and sensitivity(ies) for all occupancy sensors.

3. Network-wide programming of parameter data in a spreadsheet-like programming environment including but not limited to the following operations:
   a. Set, copy/paste an entire project site of sensor time delays.
   b. Set, copy/paste an entire project site of sensor sensitivity settings.
   c. Search based on room name and text labels.
   d. Filter by product type (i.e. LMRC-212) to allow parameter set by product.
   e. Filter by parameter value to search for product with specific configurations.

4. Network-wide firmware upgrading remotely via the BACnet/IP network.
   b. Mass firmware update of specifically selected rooms or areas.
   c. Mass firmware upgrade of specific products.

B. WattStopper Product Number: LMCS-100, LMCI-100

2.18 LMCP LIGHTING CONTROL PANELS

A. Provide lighting control panels in the locations and capacities as indicated on the plans and schedules. Each panel shall be of modular construction and consist of the following components:

1. Enclosure/Tub shall be NEMA 1, sized to accept an interior with 1 - 8 relays, 1 - 24 relays and 6 four-pole contactors, or 1 - 48 relays and 6 four-pole contactors.
2. Cover shall be configured for surface or flush wall mounting of the panel as indicated on the plans. The panel cover shall have a hinged and lockable door with restricted access to line voltage section of the panel.

3. Interior assembly shall be supplied as a factory assembled component specifically designed and listed for field installation. The interior construction shall provide total isolation of high voltage (Class 1) wiring from low voltage (Class 2) wiring within the assembled panel. The interior assembly shall include intelligence boards, power supply, DIN rails for mounting optional Class 2 control devices, and individually replaceable latching type relays. The panel interiors shall include the following features:

   a. Removable, plug-in terminal blocks with connections for all low voltage terminations.
   b. Individual terminal block, override pushbutton, and LED status light for each relay.
   c. Direct wired switch inputs associated with each relay shall support 2-wire momentary switches only.
   d. Digital inputs (four RJ-45 jacks) shall support 1-, 2-, 3-, 4-, and 8-button digital switches; digital IO modules capable of receiving 0-5V or 0-10V analog photocell inputs; digital IO modules capable of receiving momentary or maintained contact closure inputs or analog sensor inputs; digital daylighting sensors; and digital occupancy sensors. Inputs are divided into two separate digital networks, each capable of supplying 250mA to connected devices.
   e. True relay state shall be indicated by the on-board LED and shall be available to external control devices and systems via BACnet.
   f. Automatically sequenced operation of relays to reduce impact on the electrical distribution system when large loads are controlled simultaneously.
   g. Group and pattern control of relays shall be provided through a simple keypad interface from a handheld IR programmer. Any set of relays can be associated with a group for direct on/off control or pattern (scene) control via a simple programming sequence using the relay override pushbuttons and LED displays for groups 1-8 or a handheld IR programmer for groups 1-99.
   h. Relay group status for shall be provided through LED indicators for groups 1-8 and via BACnet for groups 1-99. A solid LED indicates that the last group action called for an ON state and relays in the group are on or in a mixed state.
   i. Single-pole latching relays with modular plug-in design. Relays shall provide the following ratings and features:

      1) Electrical:
         a) 30 amp ballast at 277V
         b) 20 amp ballast at 347V
         c) 20amp tungsten at 120V
         d) 30 amp resistive at 347V
         e) 1.5 HP motor at 120V
         f) 14,000 amp short circuit current rating (SCCR) at 347V
         g) Relays shall be specifically UL 20 listed for control of plug-loads

      2) Mechanical:
         a) Replaceable, ½” KO mounting with removable Class 2 wire harness.
         b) Actuator on relay housing provides manual override and visual status indication, accessible from Class 2 section of panel.
c) Dual line and load terminals each support two #14 - #12 solid or stranded conductors.

d) Tested to 300,000 mechanical on/off cycles.

4. Isolated low voltage contacts provide for true relay status feedback and pilot light indication.

5. Power supply shall be a multi-voltage transformer assembly with rated power to supply all electronics, occupancy sensors, switches, pilot lights, and photocells as necessary to meet the project requirements. Power supply to have internal overcurrent protection with automatic reset and metal oxide varistor protection.

6. Where indicated, lighting control panels designated for control of emergency lighting shall be provided with factory installed provision for automatic bypass of relays controlling emergency circuits upon loss of normal power. Panels shall be properly listed and labeled for use on emergency lighting circuits and shall meet the requirements of UL924 and NFPA 70 - Article 700.

7. Integral system clock shall provide scheduling capabilities for panel-only projects without DLM segment networks or BAS control.
   a. Each panel shall include digital clock capability able to issue system wide automation commands to up to (11) eleven other panels for a total of (12) twelve networked lighting control panels. The clock shall provide capability for up to 254 independent schedule events per panel for each of the ninety-nine system wide channel groups.
   b. The clock capability of each panel shall support the time-based energy saving requirements of applicable local energy codes.
   c. The clock module shall provide astronomic capabilities, time delays, blink warning, daylight savings, and holiday functions and will include a battery back up for the clock function and program retention in non-volatile FLASH memory. Clocks that require multiple events to meet local code lighting shut off requirements shall not be allowed.
   d. The clock capability of each panel shall operate on a basis of ON/OFF or Normal Hours/After Hours messages to automation groups that implement pre-configured control scenarios. Scenarios shall include:
      1) Scheduled ON / OFF
      2) Manual ON / Scheduled OFF
      3) Astro ON / OFF (or Photo ON / OFF)
      4) Astro and Schedule ON / OFF (or Photo and Schedule ON / OFF)
   e. The user interface shall be a portable IR handheld remote control capable of programming any panel in the system (LMCT-100)
   f. The clock capability of each panel shall employ non-volatile memory and shall retain user programming and time for a minimum of 10 years.
   g. Schedules programmed into the clock of any one panel shall be capable of executing panel local schedule or Dark/Light (photocell or Astro) events for that panel in the event that global network communication is lost. Lighting control panels that are not capable of executing events independently of the global network shall not be acceptable.

8. The lighting control panel can operate as a stand-alone system, or can support schedule, group, and photocell control functions, as configured in a Segment Manager controller, via a segment network connection.

9. The lighting control panel shall support digital communications to facilitate the extension of control to include interoperation with building automation systems and other intelligent field devices. Digital communications shall be RS485 MS/TP-based using the BACnet® protocol.
a. The panel shall have provision for an individual BACnet device ID and shall support the full 222 range (0 – 4,193,304). The device ID description property shall be writable via the network to allow unique identification of the lighting control panel on the network.

b. The panel shall support MS/TP MAC addresses in the range of 0 – 127 and baud rates of 9600k, 38400k, 76800k, and 115.2k bits per second.

c. Lighting control relays shall be controllable as binary output objects in the instance range of 1 – 64. The state of each relay shall be readable and writable by the BAS via the object present value property.

d. Lighting control relays shall report their true on/off state as binary input objects in the instance range of 1 – 64.

e. The 99 group Normal Hours/After Hours control objects associated with the panel shall be represented by binary value objects in the instance range of 201 – 299. The occupancy state of each channel group shall be readable and writable by the BAS via the object present value property. Commanding 1 to a channel group will put all relays associated with the channel into the normal hours mode. Commanding 0 or NULL shall put the relays into the after-hours mode.

f. Setup and commissioning of the panel shall not require manufacturer-specific software or a computer. All configuration of the lighting control panel shall be performed using standard BACnet objects or via the handheld IR programming remote. Provide BACnet objects for panel setup and control as follows:

1) Binary output objects in the instance range of 1 – 64 (one per relay) for on/off control of relays.
2) Binary value objects in the instance range of 1 – 99 (one per channel) for normal hours/after-hours schedule control.
3) Binary input objects in the instance range of 1 – 64 (one per relay) for reading true on/off state of the relays.
4) Analog value objects in the instance range of 101 – 199 (one per channel group) shall assign a blink warn time value to each channel. A value of 5 shall activate the blink warn feature for the channel and set a 5-minute grace-time period. A value of 250 shall activate the sweep feature for the channel and enable the use of sweep type automatic wall switches.

g. The description property for all objects shall be writable via the network and shall be saved in non-volatile memory within the panel.

h. The BO and BV 1 – 99 objects shall support BACnet priority array with a relinquish default of off and after hours respectively. Prioritized writes to the channel BV objects shall propagate prioritized control to each member relay in a way analogous to the BACnet Channel object described in addendum aa. (http://www.bacnet.org/Addenda/Add-135-2010aa.pdf)

i. Panel-aggregate control of relay Force Off at priority 2 shall be available via a single BV5 object. Force On at priority 1 shall be available via a single BV4 object.

j. Lockout of all digital switch buttons connected to a given panel shall be command-able via a single BV2 object. The lock status of any connected switch station shall be represented as BV101-196.

10. WattStopper Product Number: LMCP8, LMCP24 or LMCP48
2.19 USER INTERFACE

A. Each lighting control panel system shall be supplied with at least (1) handheld configuration tool (LMCT-100). As a remote programming interface the configuration tool shall allow setup, configuration, and diagnostics of the panel without the need for software or connection of a computer. The user interface shall have the following panel-specific functions as a minimum:

1. Set network parameters including panel device ID, MS/TP MAC address, baud rate and max master range.
2. Relay Group creation of up to 99 groups. Group creation shall result in programming of all seven key relay parameters for member relays. The seven parameters are as follows: After-hours Override Time Delay, Normal Hours Override Time Delay, Action on Transition to Normal Hours, Action on Transition to After Hours, Sensor Action During Normal Hours, Sensor Action During After Hours, Blink-Warn Time for After Hours.
3. Program up to 254 separate scheduled events. Events shall occur on seven day intervals with each day selectable as active or inactive, and shall be configurable as to whether the event is active on holidays. Holidays are also defined through the User Interface.
4. Program up to 32 separate Dark/Light events. Events shall have a selectable source as either calculated Astro with delay, or a digital IO module with an integral 0-5V or 0-10V analog photocell. Dark/Light events shall occur on seven day intervals with each day selectable as active or inactive, and shall be configurable as to whether the event is active on holidays.
5. Button binding of digital switches to groups shall be accessible via the handheld IR remote and accomplished from the digital switch station.
6. Programming of panel location information shall be accomplished by the handheld IR remote and include at a minimum LAT, LON, DST zone, and an approximate city/state location.
7. An additional handheld IR remote may optionally be specified to be permanently mounted to the panel interior via a retractable anti-theft lanyard to allow for convenient programming of the panel while assuring that the handheld programmer is always present at that panel. An unlimited number of handheld IR remotes may also be purchased for facilities staff as determined by the end user’s representative.

B. WattStopper Product Number: LMCT-100

2.20 EMERGENCY LIGHTING CONTROL DEVICES

A. Emergency Lighting Control Unit – A UL 924 listed device that monitors a switched circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include:

1. 120/277 volts, 50/60 Hz, 20 amp ballast rating
2. Push to test button
3. Auxiliary contact for remote test or fire alarm system interface

B. WattStopper Product Numbers: ELCU-100, ELCU-200.
PART 3 - EXECUTION

3.1 PRE-INSTALLATION MEETING

A. A factory authorized manufacturer’s representative shall provide the electrical contractor a functional overview of the lighting control system prior to installation. The contractor shall schedule the pre-installation site visit after receipt of approved submittals to review the following:
   1. Confirm the location and mounting of all digital devices, with special attention to placement of occupancy and daylighting sensors.
   2. Review the specifications for low voltage control wiring and termination.
   3. Discuss the functionality and configuration of all products, including sequences of operation, per design requirements.
   4. Discuss requirements for integration with other trades.

3.2 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 SENSOR INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.4 CONTACTOR INSTALLATION

A. Comply with NECA 1.

B. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.5 WIRING INSTALLATION

A. Comply with NECA 1.
B. Wiring Method: Comply with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 3/4 inch.

C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.6 IDENTIFICATION

A. Identify components and power and control wiring according to Section 26 05 53 "Identification for Electrical Systems."
   1. Identify controlled circuits in lighting contactors.
   2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate lighting control devices and perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Lighting control devices will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 FACTORY SERVICES

A. Upon completion of the installation, the manufacturer's factory authorized representative shall start up and verify a complete fully functional system.

B. The electrical contractor shall provide both the manufacturer and the electrical engineer with three weeks written notice of the system start up and adjustment date.
C. Upon completion of the system start up, the factory-authorized technician shall provide the proper training to the owner's personnel on the adjustment and maintenance of the system.

3.9 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.10 ACCEPTANCE TESTING SUPPORT SERVICES

A. On all California projects, a certified lighting controls acceptance test technician (CLCATT) must verify the installation of the lighting control system. Manufacturer should include an extra day of factory technician’s time to assist the CLCATT review the functionality and settings of the lighting control hardware per the requirements in the California State forms. It will be the CLCATT’s responsibility to create and complete any forms required for the commissioning process, although the manufacturer or contractor may offer spreadsheets and/or printouts to assist the CLCATT with this task.

3.11 COMMISSIONING SUPPORT SERVICES

A. On this project, a commissioning agent will be hired to verify the installation and programming of all building systems, which includes the lighting control system. Manufacturer should include an extra day of technician’s time to review the functionality and settings of the lighting control hardware with the commissioning agent, including reviewing submittal drawings and ensuring that instructions on how to configure each device are readily available. Manufacturer is NOT responsible for helping the commissioning agent inspect the individual devices. It will be the commissioning agent’s responsibility to create and complete any forms required for the commissioning process, although the manufacturer or contractor may offer spreadsheets and/or printouts to assist the agent with this task.

B. The commissioning agent shall work with the electrical contractor during installation of the lighting control hardware to become familiar with the specific products. The agent may also accompany the manufacturer’s technicians during their start-up work to better understand the process of testing, calibration and configuration of the products. However, the contractor and manufacturer shall ensure that interfacing with the agent does not prevent them from completing the requirements outlined in the contract documents.
3.12 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
   1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

C. Provide a laptop computer with the lighting programming already installed in the laptop computer. The laptop computer shall be the latest version of HP or DELL computer with 6G capable with 10 meg of memory spare capacity.

3.13 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 26 51 19 "LED Interior Lighting", Section 26 56 19 "LED Exterior Lighting" and Section 26 63 15 "Planetarium Lighting Technology (PLTS)".

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION
SECTION 261219 – PAD MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes pad-mounted, liquid-filled, medium-voltage distribution transformers, with primary and secondary bushings within or without air-terminal enclosures.

1.3 DEFINITIONS

A. BIL: Basic Impulse Insulation Level.
B. Bushing: An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier, conducting or otherwise, for insulating the conductor from the barrier and conducting current from one side of the barrier to the other.
C. Bushing Elbow: An insulated device used to connect insulated conductors to separable insulated connectors on dead-front, pad-mounted transformers and to provide a fully insulated connection. This is also called an "elbow connector."
D. Bushing Insert: That component of a separable insulated connector that is inserted into a bushing well to complete a dead-front, load break or non-load break, separable insulated connector (bushing).
E. Bushing Well: A component of a separable insulated connector, either permanently welded or clamped to an enclosure wall or barrier, having a cavity that receives a replaceable component (bushing insert) to complete the separable insulated connector (bushing).
F. Elbow Connector: See "bushing elbow" above.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
B. Shop Drawings: For pad-mounted, liquid-filled, medium-voltage transformers.
   1. Include plans and elevations showing major components and features.
      a. Include a plan view and cross section of equipment base, showing clearances, required workspace, and locations of penetrations for grounding and conduits.
2. Include details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include single-line diagram.
4. Include list of materials.
5. Include nameplate data.
6. Manufacturer's published time-current curves of the transformer high-voltage fuses, with transformer damage curve, inrush curve, and thru fault current indicated.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:
   1. Provide ¼“ scale drawing demonstrating that installation has been coordinated with work of other trades. Use actual dimensions from approved equipment submittals to coordinate layout and installation of substation and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels. Include utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.

B. Qualification Data: For testing agency.

C. Seismic Qualification Certificates: For transformer assembly, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For transformers, signed by product manufacturer.

E. Source quality-control reports.

F. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member Company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2.

C. Comply with IEEE C57.12.00.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."

2. Equipment anchorage is not a deferred submittal nor a delegated design item. Refer to details on the drawings for anchorage requirements.

B. Windings Material: Copper.

C. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, fully shielded, separable-elbow type, suitable for plugging into the inserts provided in the high-voltage section of the transformer. Connected in each phase of incoming circuit and ahead of any disconnecting device.

D. Winding Connections: The connection of windings and terminal markings shall comply with IEEE C57.12.70.

E. Efficiency: Comply with 10 CFR 431, Subpart K.

F. Insulation: Transformer kVA rating shall be as follows: The average winding temperature rise above a 30 deg C ambient temperature shall not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested according to IEEE C57.12.90, using combination of connections and taps that give the highest average winding temperature rise.

G. Tap Changer: External handle, for de-energized operation.

H. Tank: Sealed, with welded-on cover. Designed to withstand internal pressure of not less than 7 psi (50 kPa) without permanent distortion and 15 psig (104 kPa) without rupture. Comply with IEEE C57.12.36.

I. Enclosure Integrity: Comply with IEEE C57.12.28 for pad-mounted enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to the public.

J. Mounting: An integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.

K. Insulating Liquids:
1. Less-Flammable Liquids:
   a. Edible-Seed-Oil-Based Dielectric: Listed and labeled by an NRTL as complying with CEC 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D92. Liquid shall be biodegradable and nontoxic, having passed the Organisation for Economic Co-operation and Development G.L.203 with zero mortality, and shall be certified by the U.S. Environmental Protection Agency as biodegradable, meeting Environmental Technology Verification requirements.

L. Sound level shall comply with NEMA TR 1 requirements.

M. Corrosion Protection:
   1. Fabricate front sill, hood, and tank base of single-compartment transformers from stainless steel according to ASTM A167, Type 304 or 304L, not less than No. 13 U.S. gage, complying with requirements of IEEE C57.12.28 and IEEE C57.12.29, standard color green.
   2. Base and Cabinets of Two Compartment Transformers: Fabricate from stainless steel according to ASTM A167, Type 304 or 304L, not less than No. 13 U.S. gage. Coat transformer with manufacturer's standard green color coating complying with requirements of IEEE C57.12.28 and IEEE C57.12.29, in manufacturer's standard color green.

2.3 THREE-PHASE TRANSFORMERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Schneider Electric.
   2. Cooper Industries, Inc.
   3. Eaton.
   4. ABB.
   5. General Electric Company.

B. Description:
   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

C. Compartment Construction:
   1. Double-Compartment Construction: Individual compartments for high- and low-voltage sections, formed by steel isolating barriers that extend full height and depth of compartments, with hinged, lift-off doors and three-point latching, with a stop in the open position and provision for padlocking.

D. Primary Fusing: Designed and rated to provide thermal protection of transformer by sensing overcurrent and high liquid temperature.
   1. 150-kV BIL current-limiting fuses, conforming to requirements of IEEE C37.47.
   2. Interrupting Rating: 50,000 rms A symmetrical at system voltage.
4. Provide bayonet fuse assembly with an oil retention valve and an external drip shield inside the housing to eliminate or minimize oil spills. Valve shall close when fuse holder is removed and an external drip shield is installed.

5. Provide a conspicuously displayed warning adjacent to bayonet fuse(s), cautioning against removing or inserting fuses unless transformer has been de-energized and tank pressure has been released.

E. High-Voltage Section: Dead-front design.

1. To connect primary cable, use separable insulated connectors; coordinated with and complying with requirements of Section 26 05 13 "Medium-Voltage Cables." Bushings shall be one-piece units, with ampere and BIL ratings the same as connectors.

2. Bushing inserts and feed-through inserts:
   a. Conform to the requirements of IEEE 386.
   b. Rated at 200 A, with voltage class matching connectors. Provide a parking stand near each bushing well. Parking stands shall be equipped with insulated standoff bushings for parking of energized load-break elbow connectors on parking stands.
   c. Provide insulated protective caps for insulating and sealing out moisture from unused bushing inserts and insulated standoff bushings.

3. Bushing wells configured for loop-feed application.


5. Dead-front surge arresters.

6. Tap-changer operator.

7. Load-Break Switch:
   a. Radial-feed, liquid-immersed type with voltage class and BIL matching that of separable connectors, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12 kA rms symmetrical.
   b. Loop-feed sectionalizing switches, using three two-position, liquid-immersed-type switches for closed transition loop-feed and sectionalizing operation. Voltage class and BIL shall match that of separable connectors, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12 kA rms symmetrical. Switch operation shall be as follows:
      1) Position I: Line A connected to line B and both lines connected to the transformer.
      2) Position II: Transformer connected to line A only.
      3) Position III: Transformer connected to line B only.
      4) Position IV: Transformer disconnected and line A not connected to line B.
      5) Position V: Transformer disconnected and line A connected to line B.

8. Ground pad.

F. Low-Voltage Section:

1. Bushings with spade terminals drilled for terminating the number of conductors indicated on the Drawings, and the lugs that comply with requirements of Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

2. Metering: Coordinated with and complying with requirements of Section 26 27 13 "Electricity Metering." Install the following:
   a. Sensors.
   b. BAS interface.
   c. Kilowatt-hour meter.
   d. Kilowatt-hour demand meter.

G. Transformer Accessories:
1. Drain and filter connection.
2. Filling and top filter press connections.
3. Pressure-vacuum gauge.
4. Dial-type analog thermometer with alarm contacts.
5. Magnetic liquid level indicator with high and low alarm contacts.
6. Automatically resetting pressure-relief device. Device flow shall be as recommended by manufacturer. With alarm contacts and a manual bleeder.
7. Stainless-steel ground connection pads.
9. Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. Provide with seal-in delay.

2.4 SERVICE CONDITIONS

A. Transformers shall be suitable for operation under service conditions specified as usual service conditions in IEEE C57.12.00, except for the following.
   1. Altitudes above 3300 feet.
   2. Cooling air temperature exceeds limits.
   3. Excessive load current harmonic factor.
   4. Operation above rated voltage or below rated frequency.
   5. Exposure to explosive environments.
   6. Exposure to fumes, vapors, or dust.
   7. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
   8. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
   9. Exposure to excessively high or low temperatures.
10. Unusual transportation or storage conditions.
11. Unusual grounding resistance conditions.

2.5 CONTROL NETWORK

A. Controllers: Support serial MS/TP and Ethernet IP communications, and able to communicate directly via RS-485 serial networks and Ethernet 10Base-T networks as a native device.

2.6 WARNING LABELS AND SIGNS

A. Comply with requirements for labels and signs specified in Section 26 05 53 "Identification for Electrical Systems."
   1. High-Voltage Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s). Sign legend shall be "DANGER HIGH VOLTAGE" printed in two lines of nominal 2-inch-high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.
   2. Arc Flash Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s), warning of potential electrical arc flash hazards and appropriate personal protective equipment required.
2.7 SOURCE QUALITY CONTROL

A. Provide manufacturer's certificate that the transformer design tests comply with IEEE C57.12.90.

1. Perform the following factory-certified routine tests on each transformer for this Project:
   a. Resistance.
   b. Turns ratio, polarity, and phase relation.
   c. Transformer no-load losses and excitation current at 100 percent of ratings.
   d. Transformer impedance voltage and load loss.
   e. Operation of all devices.
   f. Lightning impulse.
   g. Low frequency.
   h. Leak.
   i. Transformer no-load losses and excitation current at 110 percent of ratings.
   j. Insulation power factor.
   k. Applied potential, except that this test is not required for single-phase transformers or for three-phase Y-Y-connected transformers.
   l. Induced potential.
   m. Resistance measurements of all windings on rated voltage connection and at tap extreme connections.
   n. Ratios on rated voltage connection and at tap extreme connections.
   o. Polarity and phase relation on rated voltage connection.
   p. No-load loss at rated voltage on rated voltage connection.
   q. Exciting current at rated voltage on rated voltage connection.
   r. Impedance.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pad-mounted, liquid-filled, medium-voltage transformers upon delivery.

1. Upon delivery of transformers and prior to unloading, inspect equipment for any damage that may have occurred during shipment or storage.
2. Verify that tie rods and chains are undamaged and tight, and that all blocking and bracing is tight. Verify that there is no evidence of load shifting in transit, and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
3. Verify that there is no indication of external damage and no dents or scratches in doors and sill, tank walls, radiators and fins, or termination provisions.
4. Verify that there is no evidence of insulating-liquid leakage on transformer surfaces, at weld seams, on high- or low-voltage bushing parts, and at transformer base.
5. Verify that there is positive pressure or vacuum on tank. Check pressure gauge; it is required to read other than zero.
6. Compare transformers and accessories received with bill of materials to verify that shipment is complete. Verify that transformers and accessories conform with manufacturer's quotation and shop drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.
7. Verify presence of polychlorinated biphenyl content labeling.
8. Unload transformers carefully, observing all packing label warnings and handling instructions.
9. Open termination compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:
   1. Handle transformers carefully, in accordance with manufacturer recommendations, to avoid damage to enclosure, termination compartments, base, frame, tank, and internal components. Do not subject transformers to impact, jolting, jarring, or rough handling.
   2. Protect transformer termination compartments against entrance of dust, rain, and snow.
   3. Transport transformers upright, to avoid internal stresses on core and coil mounting assembly and to prevent trapping air in windings. Do not tilt or tip transformers.
   4. Verify that transformer weights are within rated capacity of handling equipment.
   5. Use only manufacturer-recommended points for lifting, jacking, and pulling. Use all lifting lugs when lifting transformers.
   6. Use jacks only at corners of tank base plate.
   7. Use nylon straps of same length to balance and distribute weight when handling transformers with a crane.
   8. Use spreaders or a lifting beam to obtain a vertical lift and to protect transformer from straps bearing against enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
   9. Exercise care not to damage tank base structure when handling transformer using skids or rollers. Use skids to distribute stresses over tank base when using rollers under large transformers.

C. Storage:
   1. Store transformers in accordance with manufacturer's recommendations.
   2. Transformers may be stored outdoors. If possible, store transformers at final installation locations on concrete pads. If dry concrete surfaces are unavailable, use pallets of adequate strength to protect transformers from direct contact with ground. Ensure transformer is level.
   3. Ensure that transformer storage location is clean and protected from severe conditions. Protect transformers from dirt, water, contamination, and physical damage. Do not store transformers in presence of corrosive or explosive gases. Protect transformers from weather when stored for more than three months.
   4. Store transformers with compartment doors closed.
   5. Regularly inspect transformers while in storage and maintain documentation of storage conditions, noting any discrepancies or adverse conditions. Verify that an effective pressure seal is maintained using pressure gauges. Visually check for insulating-liquid leaks and rust spots.

D. Examine areas and space conditions for compliance with requirements for pad-mounted, liquid-filled, medium-voltage transformers and other conditions affecting performance of the Work.

E. Examine roughing-in of conduits and grounding systems to verify the following:
   1. Wiring entries comply with layout requirements.
   2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will cross section barriers to reach load or line lugs.

F. Examine concrete bases for suitable conditions for transformer installation.

G. Pre-Installation Checks:
2. Remove a sample of insulating liquid according to ASTM D 923. Insulating-liquid values shall comply with NETA ATS, Table 100.4. Sample shall be tested for the following:
   b. Acid Neutralization Number: ASTM D 974.
   c. Specific Gravity: ASTM D 1298.
   d. Interfacial Tension: ASTM D 971.
   e. Color: ASTM D 1500.
   g. Water in Insulating Liquids: Comply with ASTM D 1533.
   h. Power Factor or Dissipation Factor: ASTM D 924.

H. Verify that ground connections are in place and that requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at transformer location.

I. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install transformers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."

B. Transformer shall be installed level and plumb and shall tilt less than 1.5 degrees while energized.

C. Comply with requirements for vibration isolation and seismic control devices specified in Section 26 05 29 "Hangers and Supports for Electrical Systems" and Section 26 05 48.16 "Seismic Controls for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and IEEE C2.

3.3 CONNECTIONS

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
   1. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable, with no kinks or sharp bends.
   2. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. Bond each gate section to fence post using 1/8 by 1-inch tinned flexible braided copper strap and clamps.
   3. Make joints in grounding conductors and loops by exothermic weld or compression connector.
   4. Terminate all grounding and bonding conductors on a common equipment grounding terminal on transformer enclosure.
   5. Complete transformer tank grounding and lightning arrester connections prior to making any other electrical connections.
B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
   1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
   2. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

C. Terminate medium-voltage cables in incoming section of transformers according to Section 26 05 13 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

A. Comply with installation requirements for labels and signs specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install warning signs as required to comply with 29 CFR 1910.269.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. General Field-Testing Requirements:
   b. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
   c. After installing transformer but before primary is energized, verify that grounding system at the transformer is tested at specified value or less.
   d. After installing transformer and after electrical circuitry has been energized, test for compliance with requirements.
   e. Visual and Mechanical Inspection:
      1) Verify equipment nameplate data complies with Contract Documents.
      2) Inspect bolted electrical connections for high resistance using one of the following two methods:
         a) Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
         b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.
   f. Remove and replace malfunctioning units and retest.
g. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

2. Medium-Voltage Surge Arrester Field Tests:
   a. Visual and Mechanical Inspection:
      1) Inspect physical and mechanical condition.
      2) Verify arresters are clean.
      3) Verify that ground lead on each device is individually attached to a ground bus or ground electrode.
   b. Electrical Test:
      1) Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to comply with recommended minimum insulation resistance listed in that table.
      2) Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.

3. Liquid-Filled Transformer Field Tests:
   a. Visual and Mechanical Inspection:
      1) Test dew point of tank gases if applicable.
      2) Inspect anchorage, alignment, and grounding.
      3) Verify bushings are clean.
      4) Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
      5) Verify that liquid level in tanks is within manufacturer's published tolerances.
      6) Perform specific inspections and mechanical tests recommended by manufacturer.
      7) Verify presence of transformer surge arresters and that their ratings are as specified.
      8) Verify that as-left tap connections are as specified.
   b. Electrical Tests:
      1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index shall not be less than 1.0.
      2) Perform power-factor or dissipation-factor tests on all windings according to test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.3.
      3) Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.
      4) Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.
      5) Perform turns-ratio tests at tap positions. Turns-ratio test results shall not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
      6) Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar
current readings and one lower current reading. Investigate and correct if test shows a different pattern.

7) Measure resistance of each winding at each tap connection, and record temperature-corrected winding-resistance values in the Operations and Maintenance Manual.

8) Perform an applied-voltage test on high- and low-voltage windings-to-ground. Comply with IEEE C57.12.91, Sections 10.2 and 10.9. This test is not required for single-phase transformers and for three-phase Y-Y-connected transformers.

9) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

10) Remove a sample of insulating liquid according to ASTM D 923, and perform dissolved-gas analysis according to IEEE C57.104 or ASTM D 3612.

3.6 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each transformer. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during test period, is unacceptable.

2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
   a. Adjust transformer taps.
   b. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action is performed, until satisfactory results are obtained.

4. Report:
   a. Prepare a written report covering monitoring performed and corrective action taken.

B. Infrared Inspection: Perform survey during periods of maximum possible loading. Remove all necessary covers prior to inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of transformer's electrical power connections.

2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 Deg. C at 30 Deg. C.

3. Record of Infrared Inspection: Prepare a certified report that identifies testing technician and equipment used, and lists results as follows:
   a. Description of equipment to be tested.
   b. Discrepancies.
   c. Temperature difference between area of concern and reference area.
   d. Probable cause of temperature difference.
   e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
   f. Identify load conditions at time of inspection.
   g. Provide photographs and thermograms of deficient area.
4. Act on inspection results according to recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION
SECTION 26 13 16.10 – MEDIUM VOLTAGE METAL-ENCLOSED LOAD INTERRUPTER SWITCHGEAR (AIR INTERRUPTER SWITCHES)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Medium voltage metal-enclosed switchgear with air load interrupter switches.

1.2 REFERENCES

A. ANSI/IEEE C37.20.3 - Standard for Metal-Enclosed Interrupter Switchgear.

B. ANSI/IEEE C37.20.4 - Standard for Indoor AC Medium Voltage Switches used in Metal-Enclosed Switchgear.


E. ANSI Z55.1 - Gray Finishes for Industrial Apparatus and Equipment.

F. NEMA

G. IEC 420 High-Voltage Alternating Current Switch-Fuse Combinations (Applicable sections to ensure proper coordination of the switch-fuse combination when fuses are utilized for opening the switch automatically).

H. CAN/CSA C22.2 No. 31 Switchgear Assemblies.

I. CAN/CSA C22.2 No. 193 High Voltage Full-Load Interrupter Switches.

1.3 SUBMITTALS

A. The metal-enclosed switchgear assembly shall be in accordance with the contract documents, applicable codes whichever is the most stringent.

B. The manufacturer shall furnish a detailed Bill of Material and complete set of drawings as follows:

1. Detailed front elevation.
2. Single Line
3. Base Plan
4. Schematics
5. Wiring Diagrams

C. The manufacturer shall furnish comprehensive instruction manuals covering the installation of the switchgear and the operation of its various components.
1.4 QUALITY ASSURANCE

A. Manufacturer: Company specializing in medium voltage metal-enclosed switchgear with at least five years documented experience. The manufacturer of the switchgear must be the same as the manufacturer of the load interrupter switch.

B. Equipment shall be equipped with UL label for metal-enclosed type switchgear assemblies when UL recognized components are specified.

1.5 DELIVERY, STORAGE, AND HANDLING

A. The following paragraphs apply only to the installing contractor.

B. Accept equipment on site and inspect for shipping damage.

C. Protect equipment from weather and moisture by covering with heavy plastic or canvas and by maintaining heat within enclosure in accordance with manufacturer's instructions.

PART 2 - PRODUCT

2.1 MANUFACTURERS

A. Switchgear: The metal-enclosed load interrupter switchgear shall be Square D type HVL or approved equal.

B. Fuses (Select 1 or 2)

1. The switchgear shall be equipped with a FuseLogic system to provide single-phase protection with the following features:

a. Direct acting, (15 kV up to 65 A "E" rated fuses) fuse tripping, to automatically open the manually operated load interrupter switch in the event of a blown fuse. For fuses rated higher than those shown, system shall be shunt trip operated directly from blown fuse contacts (control power required). Blocking the closing of the switch shall further prevent potential single-phasing conditions when a fuse is blown or if a fuse is not installed.

b. Prevention of potential single-phase conditions by blocking the closing of the manually operated load interrupter switch when a fuse is blown or if a fuse is not installed.

c. Three Form C auxiliary switches (1 per phase) for phase blown/missing fuse indication. One Form C auxiliary switch (1 for all 3 phases) for blown/missing fuse indication.

d. Fuses shall be fixed in position in a non-disconnect fuse mounting with provisions for removal and replacement from the front of the gear.

e. Fuses shall be UL Listed.

f. The blown fuse indicator shall be an "Extended Travel" type with a minimum of 1 inch of travel.

2. Boric acid fuses:(Boric acid cannot be used in conjunction with FuseLogic system)

a. Fuses shall be Boric acid, expulsion type, fuse holders with replaceable refills or fuse units, complete with muffler exhaust control.
b. Fuses shall be affixed in position in a non-disconnect fuse mounting with provisions for removal and replacement from the front of the gear.
c. Fuse Rating: "E" rated, size as scheduled on drawings.
d. Voltage Class: 15.0 kV.
e. Interrupting Rating: As stated above to achieve the integrated interrupting rating; 600 amps, rms symmetrical.

2.2 LOAD INTERRUPTER SWITCHGEAR ASSEMBLY

A. The metal-enclosed switchgear with load interrupter switches shall consist of a multiple section line-up, and be of outdoor non-walk-in type construction. The sections shall contain the load interrupter switches and the necessary accessory components. The equipment shall be factory-assembled (except for necessary shipping splits) and operationally checked. The assembly shall be a self-supporting, floor mounted bay and shall be securely bolted to the transformer to form an integrated structure.

B. If Square D Company's, FuseLogic system is specified, automatic fuse tripping of the switch-fuse combination shall be tested to the applicable sections of IEC 420 to ensure proper coordination. A time delay relay may be required for certain fuse ratings to ensure that any fault current present has decayed to a value the load interrupter switch can safely interrupt.

C. In establishing the requirements for the enclosure design, consideration shall be given to such relevant factors as controlled access, tamper resistance, protection from ingress of rodents and insects, and the possibility of arcing faults within the enclosure.

D. Switchgear rated 600 amps continuous shall not require ventilation openings to aid in cooling of the associated components.

E. The integrated switchgear assembly shall withstand the effects of closing, carrying and interrupting currents up to the assigned maximum short circuit rating.

F. A viewing window shall be installed in the switch enclosure and located so as to enable visible inspection of the switch blades and blown fuse indicators from outside the enclosure.

G. System Voltage: 12 kV, 3-phase, solidly grounded, 3-phase, 3-wire without neutral bus.

H. Operating Frequency: 60 Hz.

I. Maximum Short Circuit Current: 600 kA rms symmetrical.

J. Maximum Design Voltage: 15.0 kV.

K. Basic Impulse Level (BIL): 95 kV.

L. Power Frequency Withstand: 36 kV.

M. Short-Time Current (two second): 25 kA.

N. in Bus Ampacity: 600 amps, continuous.

O. Integrated Short Circuit Rating: 40 kA, rms symmetrical.
P. The above integrated short circuit ratings represent some of the most commonly used ratings, however, they will vary according to the type, brand and size of fuse. Contact the manufacturer for the integrated rating with the particular fuse chosen.

2.3 COMPONENTS

A. Load Interrupter Switch (Select 1 or 2)

1. Over-Center Mechanism
   a. The load interrupter switch shall be rated at 600 amperes continuous and interrupting; fixed mounted on NEMA class A-20 glass reinforced polyester standoff insulators; manually operated; quick-make, quick-break with the speed of operation independent of the operator. Electrical operation of the device requires a 120 VAC source. To provide for dependable operation, the device shall not rely on chains or cables to drive the blade assemblies open and closed. The spring operator assembly shall be isolated from high voltage and coupled through a direct drive shaft.

2. Stored-Energy Mechanism
   a. The load interrupter switch shall be rated at 600 amperes continuous and interrupting; and fixed mounted on NEMA class A-20 glass reinforced polyester standoff insulators. The stored-energy, manually operated mechanism shall be equipped with separate opening and closing springs. The opening spring shall be charged prior to the closing spring. Operation of the load interrupter switch shall be by means of a close/open lever. Operation shall be quick-make, quick-break with the speed of operation independent of the operator. The mechanism shall be equipped with FuseLogic an opening coil a closing coil and operated from a 120 VAC source. To provide for dependable operation, the device shall not rely on chains or cables to drive the blade assemblies open and closed. The spring operator assembly shall be isolated from high voltage and coupled through a direct drive shaft.

B. Switches shall separate current carrying paths and arcing interruption paths.

C. Switch blades shall be mounted on insulators that are attached to grounded metal barriers. Switches that utilize blades mounted on a common shaft with insulation from blade to blade rather than blade to ground are unacceptable.

D. The switch operating handle shall be permanently attached to the outside front of the switchgear and ready for immediate use, except for outdoor applications where the front of the switchgear shall be covered by a full-height solid door. Removable handles are not acceptable. The handle must operate in the conventional fashion with the switch closed with the handle in the up position and the switch open with the handle in the down position. Provisions shall be available for padlocking the switch in either the open or closed position.

E. Voltage and Short Circuit Ratings: Match ratings specified for assembly.

F. Momentary Rating: 40 kA, rms asymmetrical.

G. Fault Closing: 40 kA, rms asymmetrical.
2.4 ACCESSORIES

A. Surge Arresters (metal-oxide type): Distribution class, rated 15 kV, MCOV; one per phase.

B. Incoming Cable Termination: Cable Lug.

C. Provide double clamping lugs for terminating cables onto the switchgear terminal pads.

D. Space Heaters: For 120 VAC external source, sized by the manufacturer, with thermostats.

E. Mechanical Interlocks: The high-voltage compartment door shall be interlocked to prevent opening with the load interrupter in the closed position. The interlock must be directly attached to the operating mechanism and should not rely on long cables and linkages.

F. Key Interlocks: 2

G. Voltage and Current Transformer Options:

1. Each bay containing a circuit interrupter shall include the following as shown on the drawings:
   a. PowerLogic Circuit Monitor, with digital display with waveform capture wired for communications to other devices.
   b. Ammeter with Selector Switch, 1% Accuracy.
   c. Voltmeter with Selector Switch, 1% Accuracy.
   d. MegaWatt Meter
   e. MegaWatt Demand with 15-minute interval
   f. MegaVAR Meter
   g. Power Factor Meter
   h. Frequency Meter
   i. Watt-hour Meter, 2 element

H. Metering Options:

1. Each bay containing a circuit interrupter shall include the following as shown on the drawings:

   a. PowerLogic Circuit Monitor, with digital display with waveform capture wired for communications to other devices.
   b. Ammeter with Selector Switch, 1% Accuracy.
   c. Voltmeter with Selector Switch, 1% Accuracy.
   d. MegaWatt Meter
   e. MegaWatt Demand with 15-minute interval
   f. MegaVAR Meter
   g. Power Factor Meter
   h. Frequency Meter
   i. Watt-hour Meter, 2 element

I. Automatic Load Transfer Control:

1. An automatic load transfer system shall be provided for a Main-Main (Common-Bus Primary-Selective System) arrangement. The system shall automatically control motor operated load interrupter switches to provide transfer of the medium-voltage circuit to an alternate circuit upon loss of voltage of the normal source(s). Potential transformers feeding phase balance and undervoltage relays are provided to continuously monitor all three phases on both sources.
   2. The system shall consist of a Modicon programmable logic controller or a relay system, potential transformers, control power transfer contactor, control selector switches, two-, three-phase, phase-balance/undervoltage (47N/27) relays, and status indicating lights.
   3. The potential transformers shall also provide 120 VAC control power for the motor operators and the logic control. Other accessories for the system include:
a. 1- Auto/Manual selector switch with indicating lights.
b. 1- Hold Return/Auto Return selector switch with indicating lights.
c. 1- Closed Transition/Open Transition selector switch with indicating lights.
d. 1- Preferred Source selector switch with indicating lights (main-main system).
e. 2- Undervoltage test push buttons.
f. 2- Close push buttons with indicating lights.
g. 2- Open bush buttons with indicating lights.

4. Sequence of operation:

a. Main - Main System:

1) The normal conditions shall be with one source (designated as preferred) closed and with the other source (designate as the alternate) open but available to provide power. A transfer is initiated after a six (6) second time delay upon detection of a phase unbalance and/or undervoltage condition on the preferred source. The normal source switch will open within three (3) cycles after the time delay. The alternate source switch will close within twelve (12) seconds after the time delay. The re-transfer will occur after the voltage on the normal source returns and stabilizes for a five (5) minute time delay. The time registers are adjustable by the use of a hand-held programmer.

2.5 FABRICATION

A. Construction: Outdoor, non-walk-in. Each equipment bay shall be a separately constructed cubicle assembled to form a rigid free-stading unit. Minimum sheet metal thickness shall be 11-gauge steel on all exterior surfaces. Adjacent bays shall be securely bolted together to form an integrated rigid structure. To assist installation and maintenance of bus and cables, the rear covers shall be removable provide split rear doors with a pad lockable handle and three-point latching. Each individual unit shall be braced to prevent distortion.

B. A viewing window shall be installed in a fixed panel of the enclosure to enable visual inspection of the disconnect blades from outside the enclosure.

C. All torqued bolts that are used for bus joints or for insulators and direct support of any current carrying parts shall be marked with a bead of highly visible bright orange "torque seal", that will readily show when a bolt has loosened.

D. The high voltage fuses (when required) and non-disconnect type fuse mountings, shall be accessible only through a separate door mechanically interlocked with the load interrupter switch, so the load interrupter switch is opened before the door is opened and that the switch cannot be closed when the door is open. Switchgear designs with full height doors for access to the fuses shall have a solid grounded metal barrier with a viewing window covering the area of the main cross bus and/or line side of the load interrupter switch. Screened or penetrable barriers which may allow intentional or inadvertent contact with energized parts shall not be permitted.

E. No energized parts should be within normal reach of the opened doorway. Four full-length vertical barriers of 3/16-inch thick glass-reinforced polyester, NEMA grade GPO-3, minimum, shall isolate the three phases of the load interrupter switch and fuses from each other and from the enclosure.

F. Height: 93.65 inches, maximum including auxiliary support members on top and bottom.

<table>
<thead>
<tr>
<th>Maximum Voltage</th>
<th>Outdoor Single / Multiple</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.0 kV</td>
<td>97 in</td>
</tr>
</tbody>
</table>
G. Main Bus shall be tin-plated copper, insulated rated 600 amps, and is to be supported from the top of the enclosure on NEMA class A-20 glass reinforced polyester standoff insulators.

H. For multiple bay lineups, include continuous ground bus through the switchgear assembly, securely connected to the steel frame of each cubicle.

I. Main bus and ground bus shall be drilled to allow for future extensions. Cutout areas with removable bolted on covers shall allow for future extension of the main bus. A knock-out shall be removable for the extension of the ground bus.

J. Outdoor units shall be designed with a sloped, drip-proof roof. The cubicles must have a door-indoor construction. The outer door shall be a bulkhead type door with three-point latching and vault type handle with provisions for padlocking. Cubicles are to be designed to allow front and rear access and shall not require the routing of line side or load side connections in front of the switch/fuse compartment.

K. The metal-enclosed switchgear shall be fully assembled, inspected and tested at the factory prior to shipment. Large line-ups shall be split to permit normal shipping and handling as well as for ease of rejoining at the job site.

2.6 FACTORY FINISHING

A. All steel parts, except galvanized (if used), shall be cleaned and a zinc-phosphate (outdoor equipment) or iron phosphate (indoor equipment) pre-treatment applied prior to paint application.

B. Paint color shall be [ANSI-61 (light gray); ANSI-49 (medium light gray)] TGIC polyester powder, applied electrostatically through air. Following paint application, parts shall be baked to produce a hard-durable finish. The average thickness of the paint film shall be 2.0 mils. Paint film shall be uniform in color and free from blisters, sags, flaking and peeling.

C. Adequacy of paint finish to inhibit the buildup of rust on ferrous metal materials shall be tested and evaluated per paragraphs 5.2.8.1-7 of ANSI C37.20.3-1987. Salt spray withstand tests in accordance with paragraph 5.2.8.4 shall be performed on a periodic basis to provide conformance to this corrosion resistance standard of at least 2500 hours minimum (outdoor equipment) or 600 hours minimum (indoor equipment).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Visually inspect switchgear for evidence of damage and verify that surfaces are ready to receive work.

B. Visually inspect to confirm that all items and accessories are in accordance with specifications and drawings.

C. Verify field measurements are as shown on shop drawings.

D. Verify that required utilities (e.g. control voltage for heater circuits on outdoor switchgear) are available, in proper location, and ready for use.

E. Beginning of installation means installer accepts existing surface conditions.
3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions, applicable requirements of the NEC and in accordance with recognized industry practices.

B. Use jumper cables, as provided by the switchgear manufacturer, to connect the primary surge arresters.

C. Bending of high-voltage cables should be avoided or minimized. All necessary bends should meet at least the minimum radii specified by the cable manufacturer.

3.3 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed by the installing contractor.

B. Visually inspect for physical damage.

C. Perform mechanical operator tests in accordance with manufacturer's instructions. Check blade alignment and arc interrupter operations of each load interrupter switch.

D. Check torque of all bolted connections, including cable terminations, either by observing the bead of indicating compound to confirm that it is still intact, or with a torque wrench to confirm the joint is tightened to the manufacturer's specifications.

E. Touch-up paint all chips and scratches with manufacturer-supplied paint and leave remaining paint with Owner.

F. Verify key interlock operation.

G. Perform insulation resistance test on each phase to ground and each phase to phase. Record results.

H. Perform low-frequency withstand tests according to ANSI/IEEE C37.20.3, paragraph 5.5.

I. Perform contact resistance test across each switch blade; report any contact resistance in excess of 50 micro-ohms.

END OF SECTION
SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.3 ACTION SUBMITTALS
   A. Product Data: For each type of product.
      1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
      2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.
   B. Shop Drawings:
      1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
      2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
      3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS
   A. Qualification Data: For testing agency.
   B. Seismic Qualification Data: Certificates, for transformers, accessories, and components, from manufacturer.
      1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
      3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
      4. Certification: Indicate that equipment meets Project and equipment seismic requirements.
   C. Coordination
   D. Provide ¼” scale drawing demonstrating that installation has been coordinated with work of other trades. Use actual dimensions from approved equipment submittals to coordinate layout.
and installation of transformers and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

E. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

F. Source quality-control reports.

G. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.

C. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Powersmiths International Corp.
2. Eaton.
5. Hammond Power Solutions Inc.
7. Sola/Hevi-Duty; a brand of Emerson Electric Co.
8. Square D; by Schneider Electric.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Equipment anchorage is not a deferred submittal nor a delegated design item. Refer to details on drawings for anchorage requirements.

1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."

2.3 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with CEC 70.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and use.

C. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.4 DISTRIBUTION TRANSFORMERS

A. Comply with CEC 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

C. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.
2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
3. Grounded to enclosure.

D. Coils: Continuous windings without splices except for taps.

1. Coil Material: Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Bolted.

E. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

F. Indoor Enclosure: Ventilated.
   1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound to seal out moisture and air.
   2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
   3. Wiring Compartment: Sized for conduit entry and wiring installation.
   4. Finish: Comply with NEMA 250.
      a. Finish Color: Gray weather-resistant enamel.

G. Outdoor Enclosure: Totally enclosed, nonventilated.
   1. NEMA 250, Type 3R: Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
   2. Wiring Compartment: Sized for conduit entry and wiring installation.
   3. Finish: Comply with NEMA 250.
      a. Finish Color: Gray weather-resistant enamel.

H. Taps for Transformers 3 kVA and Smaller: None.

I. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

J. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

K. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

L. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 80 deg C rise above 40 deg C ambient temperature.

M. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

N. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
   1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.
   2. Indicate value of K-factor on transformer nameplate.
   3. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.

O. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
   1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
   2. Include special terminal for grounding the shield.
P. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.

Q. Wall Brackets: Manufacturer's standard brackets.

2.5 IDENTIFICATION

A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 05 53 "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.
   1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
   2. Ratio tests at rated voltage connections and at all tap connections.
   3. Phase relation and polarity tests at rated voltage connections.
   4. No load losses, and excitation current and rated voltage at rated voltage connections.
   5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
   6. Applied and induced tensile tests.
   7. Regulation and efficiency at rated load and voltage.
   8. Insulation-Resistance Tests:
      a. High-voltage to ground.
      b. Low-voltage to ground.
      c. High-voltage to low-voltage.
   9. Temperature tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by CEC 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

F. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.
   1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
   2. Brace wall-mounted transformers as specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Section 03 30 00 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."
   1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.
D. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:

1. Visual and Mechanical Inspection.
   a. Inspect physical and mechanical condition.
   b. Inspect anchorage, alignment, and grounding.
   c. Verify that resilient mounts are free and that any shipping brackets have been removed.
   d. Verify the unit is clean.
   e. Perform specific inspections and mechanical tests recommended by manufacturer.
   f. Verify that as-left tap connections are as specified.
   g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:
   a. Measure resistance at each winding, tap, and bolted connection.
   b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
   c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
   d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

E. Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests:

1. Visual and Mechanical Inspection:
   a. Inspect physical and mechanical condition.
   b. Inspect anchorage, alignment, and grounding.
   c. Verify that resilient mounts are free and that any shipping brackets have been removed.
   d. Verify the unit is clean.
   e. Perform specific inspections and mechanical tests recommended by manufacturer.
   f. Verify that as-left tap connections are as specified.
   g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:
   a. Measure resistance at each winding, tap, and bolted connection.
   b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
   c. Perform power-factor or dissipation-factor tests on all windings.
   d. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
   e. Perform an excitation-current test on each phase.
   f. Perform an applied voltage test on all high- and low-voltage windings to ground.
      See IEEE C57.12.91, Sections 10.2 and 10.9.
   g. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

F. Remove and replace units that do not pass tests or inspections and retest as specified above.
G. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
   1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
   2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
   3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

H. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING
   A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

   B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING
   A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION
SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Service and distribution switchboards rated 600 V and less.
   2. Surge protection devices.
   3. Disconnecting and overcurrent protective devices.
   4. Instrumentation.
   5. Control power.
   6. Accessory components and features.
   7. Identification.

B. Related Requirements
   1. Section 26 05 72 “Overcurrent Protective Device Short-circuit Study” for fault-current and protective device short-circuit studies.
   2. Section 26 05 73 “Overcurrent Protective Device Coordination Study” for fault-current and protective device coordination studies.
   3. Section 26 05 74 "Overcurrent Protective Device Arc-Flash Hazard Study" for arc-flash analysis and arc-flash label requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
   1. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
   2. Detail enclosure types for types other than NEMA 250, Type 1.
   3. Detail bus configuration, current, and voltage ratings.
   5. Detail utility company’s metering provisions with indication of approval by utility company.
   6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
   8. Include schematic and wiring diagrams for power, signal, and control wiring.
C. Delegated Design Submittal:
   1. For arc-flash hazard analysis.
   2. For arc-flash labels.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Data: Certificates, for switchboards, overcurrent protective devices, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 01785 "Operation and Maintenance Data," include the following:
      a. Routine maintenance requirements for switchboards and all installed components.
      b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
      c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
   2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
   3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
   4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Accredited by NETA.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.9 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:
   1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding 104 deg F.
      b. Altitude: Not exceeding 6600 feet.

C. Unusual Service Conditions: NEMA PB 2, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.

D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
   2. Indicate method of providing temporary electric service.
   3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.

1.10 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Provide ¼” scale drawing demonstrating that installation has been coordinated with work of other trades. Use actual dimensions from approved equipment submittals to coordinate layout and installation of panelboard, switchgear, transformers and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Three years from date of Substantial Completion.

B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Equipment anchorage is not a deferred submittal nor a delegated design item. Refer to details on drawings for anchorage requirements.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
   2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2.2 SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. General Electric Company.
   4. Square D; by Schneider Electric.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 2.

F. Comply with CEC 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:
   1. Main Devices: Panel mounted.
   3. Sections front and rear aligned.

I. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 26 05 48.16 "Seismic Controls for Electrical Systems."
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

J. Indoor Enclosures: Steel, NEMA 250, Type 1.

K. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

L. Outdoor Enclosures: Type 3R.
   1. Finish: Factory-applied finish in manufacturer's standard color; undersurfaces treated with corrosion-resistant undercoating.
   2. Enclosure: Downward, rearward sloping roof; rear hinged doors for each section, with provisions for padlocking.
M. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
   1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.

N. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

O. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

P. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

Q. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.

R. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

S. Buses and Connections: Three phase, four wire unless otherwise indicated.
   1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
   3. Copper feeder circuit-breaker line connections.
   4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
   5. Ground Bus: 1/4-by-2-inch-hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors.
   6. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
   7. Disconnect Links:
      a. Isolate neutral bus from incoming neutral conductors.
      b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
   8. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

T. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

U. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.
2.3 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advanced Protection Technologies Inc. (APT).
   2. Eaton.
   5. Square D; by Schneider Electric.

B. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1 and Type 2.

C. Features and Accessories:
   1. Integral disconnect switch.
   2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
   3. Indicator light display for protection status.
   4. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
   5. Surge counter.

D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 300 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
   1. Line to Neutral: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
   2. Line to Ground: 1200 V for 480Y/277 V, 1200 V for 208Y/120 V.
   3. Line to Line: 2000 V for 480Y/277 V, 1000 V for 208Y/120 V.

F. SCCR: Equal or exceed 100 kA.

G. Nominal Rating: 20 kA.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
   3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
      a. Instantaneous trip.
      b. Long- and short-time pickup levels.
4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).

5. Mccb Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
   c. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   d. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
   e. Communication Capability: Circuit-breaker-mounted Universal-mounted Integral communication module with functions and features compatible with power monitoring and control system specified in Section 26.09.13 "Electrical Power Monitoring and Control."
   f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
   g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   h. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   i. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton.
   b. SIEMENS Industry, Inc.; Energy Management Division.
   c. Square D.

2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
   a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.

4. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
5. Service-Rated Switches: Labeled for use as service equipment.
6. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
   a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
   c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).

7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

D. Fuses are specified in Section 26 28 13 "Fuses."

2.5 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:

1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.

2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.

3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.


B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
   a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
   b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
   c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
   d. Megawatts: Plus or minus 1 percent.
   e. Megavars: Plus or minus 1 percent.
   f. Power Factor: Plus or minus 1 percent.
   g. Frequency: Plus or minus 0.1 percent.
   h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
   i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
   j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.6 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.
2.7 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.


D. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with requirements in Section 26 05 48.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

2.8 IDENTIFICATION

A. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

B. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.

2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.

3. Protect from moisture, dust, dirt, and debris during storage and installation.

4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.
B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 03 30 00 "Cast-in-Place Concrete."

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, surge protection devices, and instrumentation.
   1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Install spare-fuse cabinet.

I. Comply with NECA 1.

3.3 CONNECTIONS

A. Comply with requirements for terminating cable trays specified in Section 26 05 36 "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

B. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per CEC 70.

C. Support and secure conductors within the switchboard according to CEC 70.

D. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:
   1. Acceptance Testing:
      a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
      b. Test continuity of each circuit.
   2. Test ground-fault protection of equipment for service equipment per CEC 70.
   4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   5. Perform the following infrared scan tests and inspections, and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
      c. Instruments and Equipment:
         1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Switchboard will be considered defective if it does not pass tests and inspections.
F. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 "Overcurrent Protective Device Coordination Study."

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer’s written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION
SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.
   3. Electronic-grade panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.
B. GFCI: Ground-fault circuit interrupter.
C. GFEP: Ground-fault equipment protection.
D. HID: High-intensity discharge.
E. MCCB: Molded-case circuit breaker.
F. SPD: Surge protective device.
G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.
   1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
   2. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details.
   2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
   3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
   4. Detail bus configuration, current, and voltage ratings.
   5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for SPD as installed in panelboard.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Key interlock scheme drawing and sequence of operations.
10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

C. Delegated Design Submittal:
   1. For arc-flash hazard study.
   2. For arc-flash labels.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

C. Provide ¼” scale drawing demonstrating that installation has been coordinated with work of other trades. Use actual dimensions from approved equipment submittals to coordinate layout and installation of transformers and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01785 “Operation and Maintenance Data,” include the following:
   1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock.
   2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
   3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
1.8 QUALITY ASSURANCE
   A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING
   A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

1.10 FIELD CONDITIONS
   A. Environmental Limitations:
      1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
      2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
         a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
         b. Altitude: Not exceeding 6600 feet.
   B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
      1. Ambient temperatures within limits specified.
      2. Altitude not exceeding 6600 feet.
   C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
      1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electric service.
      2. Do not proceed with interruption of electric service without Owner's written permission.
      3. Comply with NFPA 70E.

1.11 WARRANTY
   A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.
      1. Panelboard Warranty Period: 18 months from date of Substantial Completion.
   B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.
      1. SPD Warranty Period: Five years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA PB 1.

E. Comply with CEC 70.

F. Enclosures: Flush and Surface-mounted, dead-front cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor Locations: NEMA 250, Type 3R.
      c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
      d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
   2. Height: 90 inches to top of trim maximum.
   3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
   4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
   5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
   6. Finishes:
      a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
      b. Back Boxes: Same finish as panels and trim.
      c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

G. Incoming Mains:
   1. Location: Convertible between top and bottom.
   2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:
      a. Plating shall run entire length of bus.
      b. Bus shall be fully rated the entire length.
2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.
7. Split Bus: Vertical buses divided into individual vertical sections.

I. Conductor Connectors: Suitable for use with conductor material and sizes.
   2. Terminations shall allow use of 75 deg C rated conductors without derating.
   3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
   4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
   5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
   6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
   7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
   8. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.

J. NRTL Label: Panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

K. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
   1. Percentage of Future Space Capacity: 50 percent.

L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
   1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings calculated in Section 26 05 73 Overcurrent Protective Device Short-Circuit Study, but not less than 10,000 A rms symmetrical.
   2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings calculated in Section 26 05 73 Overcurrent Protective Device Short-Circuit Study, but not less than 14,000 A rms symmetrical.
2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Equipment anchorage is not a deferred submittal nor a delegated design item. Refer to details on drawings for anchorage requirements.

1. The term “withstand” means “the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified.”

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2.

2.3 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
4. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker.


F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger than 125 A: Bolt-on circuit breakers.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
4. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only as indicated on schedule.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
E. Contactors in Main Bus: NEMA ICS 2, Class A, electrically or mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
   1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

F. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   4. Square D; by Schneider Electric.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents calculated in Section 26 05 73 Overcurrent Protective Device Short-Circuit Study.
   1. Thermal-Magnetic Circuit Breakers:
      a. Inverse time-current element for low-level overloads.
      b. Instantaneous magnetic trip element for short circuits.
      c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   3. Electronic Trip Circuit Breakers:
      a. RMS sensing.
      b. Field-replaceable rating plug or electronic trip.
      c. Digital display of settings, trip targets, and indicated metering displays.
      d. Multi-button keypad to access programmable functions and monitored data.
      e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
      f. Integral test jack for connection to portable test set or laptop computer.
      g. Field-Adjustable Settings:
         1) Instantaneous trip.
         2) Long- and short-time pickup levels.
         3) Long and short time adjustments.
         4) Ground-fault pickup level, time delay, and I squared T response.
   4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
   5. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
   8. MCCB Features and Accessories:
      a. Standard frame sizes, trip ratings, and number of poles.
      b. Breaker handle indicates tripped status.
2.7 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407.

D. Equipment Mounting:

1. Install panelboards on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."

2. Attach panelboard to the vertical finished or structural surface behind the panelboard.

3. Comply with requirements for seismic control devices specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim 90 inches above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
J. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.

K. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges.
   2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

M. Install filler plates in unused spaces.

N. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

O. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

P. Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 26 05 53 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 26 05 53 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers. Do not perform optional tests. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Perform the following infrared scan tests and inspections and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
      c. Instruments and Equipment:
         1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 "Overcurrent Protective Device Coordination Study."

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION
SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Straight-blade convenience, industrial-grade, isolated-ground, and tamper-resistant receptacles.
   2. GFCI receptacles.
   3. SPD receptacles.
   4. Hazardous (classified) location receptacles.
   5. Twist-locking receptacles.
   6. Pendant cord-connector devices.
   7. Cord and plug sets.
   8. Toggle switches.
   9. Wall plates.
  10. Floor service outlets.
  11. Poke-through assemblies.
  12. Prefabricated multioutlet assemblies.

1.3 DEFINITIONS

A. Abbreviations of Manufacturers’ Names:
   1. Cooper: Cooper Wiring Devices; Division of Cooper Industries, Inc.

B. BAS: Building automation system.

C. EMI: Electromagnetic interference.

D. GFCI: Ground-fault circuit interrupter.

E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

F. RFI: Radio-frequency interference.

G. SPD: Surge protective device.

H. UTP: Unshielded twisted pair.
1.4 ACTION SUBMITTALS
   A. Samples: One for each type of device and wall plate specified, in each color specified.

1.5 INFORMATIONAL SUBMITTALS
   A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For wiring devices to include in all manufacturers’ packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS
   A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.
   B. Comply with CEC 70.
   C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
      1. Connectors shall comply with UL 2459 and shall be made with stranded building wire.
      2. Devices shall comply with the requirements in this Section.
   D. Devices for Owner-Furnished Equipment:
      1. Receptacles: Match plug configurations.
      2. Cord and Plug Sets: Match equipment requirements.
   E. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STRAIGHT-BLADE RECEPCTACLES
   A. Duplex Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
      1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         a. Eaton (Arrow Hart).
         b. Hubbell Incorporated; Wiring Device-Kellems.
         c. Leviton Manufacturing Co., Inc.
         d. Pass & Seymour/Legrand (Pass & Seymour).
   B. Isolated-Ground, Duplex Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

C. Tamper-Resistant Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Labeled and complying with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

2.3 GFCI RECEPTACLES

A. General Description:

   1. 125 V, 20 A, straight blade, non-feed-through type.
   2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.
   3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton (Arrow Hart).
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. Leviton Manufacturing Co., Inc.
      d. Pass & Seymour/Legrand (Pass & Seymour).

C. Tamper-Resistant, Duplex GFCI Convenience Receptacles:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. Pass & Seymour/Legrand (Pass & Seymour).
2.4 SPD RECEPCTACLES

A. General Description: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 1449, and FS W-C-596, with integral SPD in line to ground, line to neutral, and neutral to ground.

1. 125 V, 20 A, straight-blade type.
2. SPD Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 V and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
3. Active SPD Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."

B. Duplex SPD Convenience Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand (Pass & Seymour).

C. Isolated-Ground, Duplex SPD Convenience Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand (Pass & Seymour).

2. Grounding: Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.5 HAZARDOUS (CLASSIFIED) LOCATION RECEPCTACLES

A. Hazardous (Classified) Locations Receptacles: Comply with NEMA FB 11 and UL 1010.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. EGS/Appleton Electric.
   c. Killark.

2.6 TWIST-LOCKING RECEPCTACLES

A. Twist-Lock, Single Convenience Receptacles: 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand (Pass & Seymour).
2. Grounding: Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.7 PENDANT CORD-CONNECTOR DEVICES
A. Description:
1. Matching, locking-type plug and receptacle body connector.
2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.8 CORD AND PLUG SETS
A. Description:
1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

2.9 TOGGLE SWITCHES
A. Comply with NEMA WD 1, UL 20, and FS W-S-896.
B. Switches, 120/277 V, 20 A:
1. Single Pole:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Eaton (Arrow Hart).
2) Hubbell Incorporated; Wiring Device-Kellems.
3) Leviton Manufacturing Co., Inc.
4) Pass & Seymour/Legrand (Pass & Seymour).

2. Two Pole:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Eaton (Arrow Hart).
      2) Hubbell Incorporated; Wiring Device-Kellems.
      3) Leviton Manufacturing Co., Inc.
      4) Pass & Seymour/Legrand (Pass & Seymour).

3. Three Way:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Eaton (Arrow Hart).
      2) Hubbell Incorporated; Wiring Device-Kellems.
      3) Leviton Manufacturing Co., Inc.
      4) Pass & Seymour/Legrand (Pass & Seymour).

4. Four Way:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Eaton (Arrow Hart).
      2) Hubbell Incorporated; Wiring Device-Kellems.
      3) Leviton Manufacturing Co., Inc.
      4) Pass & Seymour/Legrand (Pass & Seymour).

C. Pilot-Light Switches: 120/277 V, 20 A.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton (Arrow Hart).
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. Leviton Manufacturing Co., Inc.
      d. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Single pole, with LED-lighted handle, illuminated when switch is off.

D. Key-Operated Switches: 120/277 V, 20 A.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton (Arrow Hart).
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. Leviton Manufacturing Co., Inc.
      d. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

e. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand (Pass & Seymour).
   e. <Insert manufacturer's name>.

2.10 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.
   1. Plate-Securing Screws: Metal with head color to match plate finish.
   2. Material for Finished Spaces: 0.035-inch-thick, satin-finished, Type 302 stainless steel.
   4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.11 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Round, die-cast aluminum with satin finish.

D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

E. Data Communication Outlet: Blank cover with bushed cable opening. Two modular, keyed, color-coded, RJ-45 jacks for twisted pair cable complying with requirements in Section 27 15 13 "Communications Copper Horizontal Cabling."

2.12 POKE-THROUGH ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Hubbell Incorporated; Wiring Device-Kellems.
   2. Pass & Seymour/Legrand (Pass & Seymour).
   3. Square D; by Schneider Electric.
   4. Wiremold / Legrand.
B. Description:
1. Factory-fabricated and wired assembly of below-floor junction box with multi-channeled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.
2. Comply with UL 514 scrub water exclusion requirements.
3. Service-Outlet Assembly: Flush type with four simplex receptacles and space for four RJ-45 jacks complying with requirements in Section 27 15 13 "Communications Horizontal Twisted Pair Cabling."
4. Size: Selected to fit nominal 8-inch cored holes in floor and matched to floor thickness.
5. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
6. Closure Plug: Arranged to close unused cored openings and reestablish fire rating of floor.
7. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of two, four-pair cables that comply with requirements in Section 27 15 13 "Communications Horizontal Twisted Pair Cabling."

2.13 PREFABRICATED MULTIOUTLET ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Incorporated; Wiring Device-Kellems.
2. Wiremold / Legrand.

B. Description:
1. Two-piece surface metal raceway, with factory-wired multioutlet harness.
2. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: Metal, with manufacturer's standard finish.

D. Monument:
1. WaterSaver pedestal electrical box with ¾" hub,
   a. Single-gang catalog number E300SA, single gang, single face.
   b. Two-gang catalog number E400SA, single gang, double face and E500SA, double gang, single face.
   c. Four-gang catalog number E600SA, double gang, double face.

2. Manufacturer:
   a. Hubbell.
   b. LeGrand.
   c. Or approved equal.

3. Pedestals shall have single-piece aluminum base and housing, integral raised threaded hub, and shall contain devices as shown on drawings. Housing finish shall be brushed.

E. Multioutlet Harness:
1. Receptacles: 20-A, 125-V, NEMA WD 6 Configuration 5-20R receptacles complying with NEMA WD 1, UL 498, and FS W-C-596.
2. Receptacle Spacing: Refer to plans.
3. Wiring: No. 12 AWG solid, Type THHN copper, multi circuit, connecting alternating receptacles.
2.14 FINISHES

A. Device Color:
1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by CEC 70 or device listing.
3. SPD Devices: Blue.
4. Isolated-Ground Receptacles: As specified above, with orange triangle on face.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:
1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of CEC 70, Article 300, without pigtails.
4. Existing Conductors:
   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtail existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:
1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
   1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:
   1. Install dimmers within terms of their listing.
   2. Verify that dimmers used for fan-speed control are listed for that application.
   3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers’ device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES
A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION
A. Comply with Section 26 05 53 "Identification for Electrical Systems."
B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL
A. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
B. Perform the following tests and inspections:
   1. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
C. Tests for Convenience Receptacles:
   1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions remove malfunctioning units and replace with new ones, and retest as specified above.

D. Wiring device will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION
SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:
   a. Control circuits.
   b. Panelboards.
   c. Switchboards.
   d. Enclosed controllers.
   e. Enclosed switches.

2. Spare-fuse cabinets.

3. E-Rated Series – Medium Voltage Fuses

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
   a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
   b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.


4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software and in PDF format.

5. Coordination charts and tables and related data.

6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01770 "Contract Closeout Procedures," include the following:
1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software and in PDF format.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Bussmann, an Eaton business.
   2. Edison; a brand of Bussmann by Eaton.
   3. Littelfuse, Inc.
   4. Mersen USA.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
   1. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
   2. Type RK-5: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
   3. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with CEC 70.
E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
   1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
   2. Finish: Gray, baked enamel.
   3. Identification: "SPARE FUSES" in 1-1/2-inch-high letters on exterior of door.
   4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

2.4 MEDIUM VOLTAGE FUSES

A. Characteristics: NEMA Standards for E-rated medium voltage fuses,
   1. E-rated fuses with time current characteristics.
   2. Provide current-limiting protection for power transformers.
   3. Provide protection for high and low fault currents.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:
   1. Motor Branch Circuits: Class RK1 Class RK5, time delay.
   2. Other Branch Circuits: Class RK1, time delay Class RK5, time delay.
   3. Transformer current limiting protection.
3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Architect.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION
SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section Includes:
      1. Fusible switches.
      2. Nonfusible switches.
      3. Receptacle switches.
      4. Shunt trip switches.
      5. Molded-case circuit breakers (MCCBs).
      7. Enclosures.

1.3 DEFINITIONS
   A. NC: Normally closed.
   B. NO: Normally open.
   C. SPDT: Single pole, double throw.

1.4 INFORMATIONAL SUBMITTALS
   A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
      1. In addition to items specified in Section 01785 "Operation and Maintenance Data," include the following:
         a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.6 MAINTENANCE MATERIAL SUBMITTALS
   A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.7 QUALITY ASSURANCE
A. Testing Agency Qualifications: Accredited by NETA.
1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.8 FIELD CONDITIONS
A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 GENERAL REQUIREMENTS
A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CEC 70, by an NRTL, and marked for intended location and application.
D. Comply with CEC 70.

2.3 FUSIBLE SWITCHES
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB Inc.
2. Eaton.
5. Square D; by Schneider Electric.

B. Type HD, Heavy Duty:
1. Single throw.
2. Three pole.
3. 600-V ac.
4. 1200 A and smaller.
5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
6. Lockable handle with capability to accept three padlocks and interlocked with cover in closed position.

C. Accessories:
1. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 240-V ac.
2. Hookstick Handle: Allows use of a hookstick to operate the handle.
3. Lugs: Mechanical type, suitable for number, size, and conductor material.
4. Service-Rated Switches: Labeled for use as service equipment.

2.4 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
2. General Electric Company.
4. Square D; by Schneider Electric.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Three Pole, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Accessories:
1. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 240-V ac.
2. Hookstick Handle: Allows use of a hookstick to operate the handle.
3. Lugs: Mechanical type, suitable for number, size, and conductor material.
4. Service-Rated Switches: Labeled for use as service equipment.

2.5 SHUNT TRIP SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bussmann, an Eaton business.
2. Littelfuse, Inc.
3. Mersen USA.

B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.

C. Type HD, Heavy-Duty, Three Pole, Single-Throw Nonfusible Switch: 600-V ac, amperage as indicated on construction documents. 30 Amp minimum; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power source of enough capacity to operate shunt trip, pilot, indicating and control devices.

E. Accessories:
   1. Oiltight key switch for key-to-test function.
   2. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
   3. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.
   4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
   5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 240-V ac.
   6. Hookstick Handle: Allows use of a hookstick to operate the handle.
   7. Lugs: Mechanical type, suitable for number, size, and conductor material.
   8. Service-Rated Switches: Labeled for use as service equipment.

2.6 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. General Electric Company.
   4. Square D; by Schneider Electric.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated Series rating is not allowed.
E. MCCBs shall be equipped with a device for locking in the isolated position.

F. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.


I. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
   1. Instantaneous trip.
   2. Long- and short-time pickup levels.
   3. Long- and short-time time adjustments.
   4. Ground-fault pickup level, time delay, and I-squared t response.

J. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

K. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

L. Features and Accessories:
   1. Standard frame sizes, trip ratings, and number of poles.
   2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
   3. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
   4. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   5. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   6. Alarm Switch: One NC contact that operates only when circuit breaker has tripped.
   7. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
   8. Electrical Operator: Provide remote control for on, off, and reset operations.

2.7 ENCLOSED SWITCHES AND CIRCUIT BREAKERS

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (NEMA 250 Types 3R, 12).

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.
D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with
the operating mechanism being an integral part of the box, not the cover. The cover interlock
mechanism shall have an externally operated override. The override shall not permanently
disable the interlock mechanism, which shall return to the locked position once the override is
released. The tool used to override the cover interlock mechanism shall not be required to enter
the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual
cover interlock mechanism to prevent unintentional opening of the enclosure cover when the
circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is
open.

F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their
use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for
compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
   1. Commencement of work shall indicate Installer's acceptance of the areas and conditions
      as satisfactory.

3.2 PREPARATION

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by
Owner or others unless permitted under the following conditions and then only after arranging
to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager no fewer than seven days in advance of proposed
      interruption of electric service.
   2. Indicate method of providing temporary electric service.
   3. Do not proceed with interruption of electric service without Owner's written permission.
   4. Comply with NFPA 70E.

3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the
following environmental ratings.
   1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
   2. Outdoor Locations: NEMA 250, Type 3R
   3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
   4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
   5. Hazardous Areas Indicated on Drawings: NEMA 250, Type 9 with cover attached by
      Type 316 stainless steel bolts.
3.4 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

D. Install fuses in fusible devices.

E. Comply with CEC 70 and NECA 1.

3.5 IDENTIFICATION

A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:
   a. Inspect physical and mechanical condition.
   b. Inspect anchorage, alignment, grounding, and clearances.
   c. Verify that the unit is clean.
   d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
   e. Verify that fuse sizes and types match the Specifications and Drawings.
   f. Verify that each fuse has adequate mechanical support and contact integrity.
   g. Inspect bolted electrical connections for high resistance using one of the two following methods:
      1) Use a low-resistance ohmmeter.
         a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.

i. Verify correct phase barrier installation.

j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

D. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and clearances.

d. Verify that the unit is clean.

e. Operate the circuit breaker to ensure smooth operation.

f. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

   a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

   a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

   g. Inspect operating mechanism, contacts, and chutes in unsealed units.

   h. Perform adjustments for final protective device settings in accordance with the coordination study.
2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-
      resistance ohmmeter. Compare bolted connection resistance values to values of
      similar connections. Investigate values that deviate from adjacent poles or similar
      switches by more than 50 percent of the lowest value.
   b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase
      and phase-to-ground with circuit breaker closed, and across each open pole. Apply
      voltage in accordance with manufacturer's published data. In the absence of
      manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate
      values of insulation resistance less than those published in Table 100.1 or as
      recommended in manufacturer's published data.
   c. Perform a contact/pole resistance test. Drop values shall not exceed the high level
      of the manufacturer's published data. If manufacturer's published data are not
      available, investigate values that deviate from adjacent poles or similar switches by
      more than 50 percent of the lowest value.
   d. Perform insulation resistance tests on all control wiring with respect to ground.
      Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V
      rated cable. Test duration shall be one minute. For units with solid state
      components, follow manufacturer's recommendation. Insulation resistance values
      shall be no less than two megohms.
   e. Determine the following by primary current injection:
      1) Long-time pickup and delay. Pickup values shall be as specified. Trip
         characteristic shall not exceed manufacturer's published time-current
         characteristic tolerance band, including adjustment factors.
      2) Short-time pickup and delay. Short-time pickup values shall be as specified.
         Trip characteristic shall not exceed manufacturer's published time-current
         characteristic tolerance band, including adjustment factors.
      3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as
         specified. Trip characteristic shall not exceed manufacturer's published
         time-current characteristic tolerance band, including adjustment factors.
      4) Instantaneous pickup. Instantaneous pickup values shall be as specified
         and within manufacturer's published tolerances.
   f. Test functionality of the trip unit by means of primary current injection. Pickup
      values and trip characteristics shall be as specified and within manufacturer's
      published tolerances.
   g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance
      with manufacturer's published data. Minimum pickup voltage of the shunt trip and
      close coils shall be as indicated by manufacturer.
   h. Verify correct operation of auxiliary features such as trip and pickup indicators;
      zone interlocking; electrical close and trip operation; trip-free, anti-pump function;
      and trip unit battery condition. Reset all trip logs and indicators. Investigate units
      that do not function as designed.
   i. Verify operation of charging mechanism. Investigate units that do not function as
      designed.
   3. Correct malfunctioning units on-site, where possible, and retest to demonstrate
      compliance; otherwise, replace with new units and retest.
   4. Perform the following infrared scan tests and inspections and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days
         after Final Acceptance, perform an infrared scan of each enclosed switch and
         circuit breaker. Remove front panels so joints and connections are accessible to
         portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.

c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.
   1. Test procedures used.
   2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
   3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.7 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 "Overcurrent Protective Device Coordination Study."

END OF SECTION
SECTION 263213.13 - DIESEL EMERGENCY ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes packaged diesel engine generators for emergency use with the following features:
      1. Diesel engine.
      2. Diesel fuel-oil system.
      3. Control and monitoring.
      4. Generator overcurrent and fault protection.
      5. Generator, exciter, and voltage regulator.
      7. Outdoor engine generator enclosure.
      8. Vibration isolation devices.

   B. Related Requirements:
      1. Section 26 36 00 "Transfer Switches" for transfer switches, including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.3 DEFINITIONS
   A. EPS: Emergency power supply.

   B. EPSS: Emergency power supply system.

   C. Operational Bandwidth: The total variation, from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product.
      1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
      2. Include thermal damage curve for generator.
      3. Include time-current characteristic curves for generator protective device.
      4. Include fuel consumption in gallons per hour at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
      5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include airflow requirements for cooling and combustion air in cubic feet per minute at 0.8 power factor, with air-supply temperature of 95, 80, 70, and 50 deg F. Provide Drawings indicating requirements and limitations for location of air intake and exhausts.

7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:
   1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Identify fluid drain ports and clearance requirements for proper fluid drain.
   4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and supported equipment. Include base weights.
   6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For installer manufacturer and testing agency.

B. Seismic Qualification Data: Certificates for engine generator, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: With engine and generator mounted on rails, identify center of gravity and total weight, supplied enclosure, external silencer, subbase-mounted fuel tank, and each piece of equipment not integral to the engine generator, and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source Quality-Control Reports: Including, but not limited to, the following:
   1. Certified summary of prototype-unit test report.
   2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
   4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
   6. Report of exhaust emissions showing compliance with applicable regulations.

D. California Diesel operation Permit.
   1. Provide and assist owner in obtaining permits to construct and operate diesel engine generator.
   2. Provide completed forms including all unit required information to owner.
3. Assist owner in submission and procurement of permits

E. Provide ¼” scale drawing demonstrating that installation has been coordinated with work of other trades. Use actual dimensions from approved equipment submittals to coordinate layout and installation of generator and components with other construction including architectural and structural elements, conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

F. Field quality-control reports.

G. Warranty: For special warranty.

1.9 WARRANTY

1. Warranty Period: 5 years from date of Substantial Completion.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01785 "Operation and Maintenance Data," include the following:
   a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
   b. Operating instructions laminated and mounted adjacent to generator location.
   c. Training plan.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Cummins Power Generation.

B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, subbase fuel tank, day tank, engine generator, batteries, battery racks, silencers, load banks, sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Equipment anchorage is not a deferred submittal nor a delegated design item. Refer to details on drawings for anchorage requirements.
   1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels. Water shall be substituted for diesel fuel in fuel tank during test.
   3. Component Importance Factor: 1.5.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:
   2. Comply with NFPA 70.
   4. Comply with NFPA 110 requirements for Level 1 EPSS.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Comply with EPA Tier 3 requirements and applicable state and local government requirements.

F. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator, including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
   1. Ambient Temperature: 41 to 104 deg F.
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 60 feet.

H. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. EPSS Class: Engine generator shall be classified as a Class 2 according to NFPA 110.

D. Induction Method: Turbocharged.

E. Governor: Adjustable isochronous, with speed sensing.

F. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

G. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.

2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of components.

H. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage, from no load to full load.

2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.

3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency, from no load to full load.

4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.

6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.

8. Start Time: Comply with NFPA 110, Type 10 system requirements.

2.4 DIESEL ENGINE

A. Fuel: ASTM D 975 diesel fuel oil, Grade 2-D S15.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid mounted.
   1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
   2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
   3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and with UL 499.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.
   1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
   2. Size of Radiator: Adequate to contain expansion of total system coolant, from cold start to 110 percent load condition.
   3. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
      a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
      b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
   1. Minimum sound attenuation of 25 dB at 500 Hz.
   2. Sound level measured at a distance of 25 feet from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System: 12 V electric, with negative ground.
1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified.
4. Battery: Nickel cadmium, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
9. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for nickel-cadmium batteries. Unit shall comply with UL 1236 and include the following features:
   a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
   b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg F to 140 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.
   c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
   e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
   f. Enclosure and Mounting: NEMA 250, Type 1 wall-mounted cabinet.

2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 30.

B. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

C. Fuel Filtering: Remove water and contaminants larger than 1 micron.

D. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
E. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:

1. Tank level indicator.
2. Fuel-Tank Capacity: Minimum 133 percent of total fuel required for periodic maintenance operations between fuel refills, plus fuel for the hours of continuous operation for indicated EPSS class.
3. Leak detection in interstitial space.
4. Vandal-resistant fill cap.
5. Containment Provisions: Comply with requirements of authorities having jurisdiction including the following:
   a. CFC Sec. 5004.2.2.4.
   b. CFC Sec. 5004.2.2.5.
   c. CFC Sec. 5003.5.
   d. CFC Sec. 5704.2.3.1.
   e. CFC Sec. 5704.2.3.2.
   f. CFC Sec. 5704.2.7.3.2.
   g. CFC Sec. 5704.2.7.3.3.
   h. CFC Sec. 5704.4.2.4.
   i. CFC Sec. 5704.2.9.7.8.
6. Exterior walkway for generator enclosure access. Maximum height from top of access panel to walkway surface shall be 7.5 feet

2.6 CONTROL AND MONITORING

A. Automatic-Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Provide minimum run time control set for 30 minutes, with override only by operation of a remote emergency-stop switch.

C. Comply with UL 508A.

D. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.


E. Control and Monitoring Panel:

1. Digital controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Instruments: Located on the control and monitoring panel and viewable during operation.
   a. Engine lubricating-oil pressure gage.
   b. Engine-coolant temperature gage.
   c. DC voltmeter (alternator battery charging).
d. Running-time meter.
e. AC voltmeter, for each phase.
f. AC ammeter, for each phase.
g. AC frequency meter.
h. Generator-voltage-adjusting rheostat.

3. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication as required by NFPA 110 for Level 1 system, including the following:
   a. Cranking control equipment.
   c. Control switch not in automatic position alarm.
   d. Overcrank alarm.
   e. Overcrank shutdown device.
   f. Low water temperature alarm.
   g. High engine temperature pre-alarm.
   h. High engine temperature.
   i. High engine temperature shutdown device.
   j. Overspeed alarm.
   k. Overspeed shutdown device.
   l. Low-fuel main tank.
      1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for the duration required for the indicated EPSS class.

   m. Coolant low-level alarm.
   n. Coolant low-level shutdown device.
   o. Coolant high-temperature alarm.
   q. Coolant high-temperature shutdown device.
   r. EPS load indicator.
   s. Battery high-voltage alarm.
   t. Low-cranking voltage alarm.
   u. Battery-charger malfunction alarm.
   v. Battery low-voltage alarm.
   w. Lamp test.
   x. Contacts for local and remote common alarm.
   y. Remote manual-stop shutdown device.
   z. Air shutdown damper alarm when used.
   aa. Air shutdown damper shutdown device when used.
   bb. Generator overcurrent-protective-device not-closed alarm.

F. Connection to Datalog:
   1. Provide connections for datalink transmission of indications to remote data terminals via ModBus LonWorks or Ethernet. Data system connections to terminals are covered in Section 26 09 13 "Electrical Power Monitoring and Control."

G. Common Remote Panel with Common Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

H. Remote Alarm Annunciator: Comply with NFPA 99. An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.
1. Overcrank alarm.
2. Coolant low-temperature alarm.
3. High engine temperature prealarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low-fuel main tank alarm.
8. Low coolant level alarm.
9. Low-cranking voltage alarm.
10. Contacts for local and remote common alarm.
12. Air shutdown damper when used.
14. Control switch not in automatic position alarm.
15. Lamp test.
16. Low-cranking voltage alarm.
17. Generator overcurrent protective device not closed.

I. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

J. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

D. Ground-Fault Indication: Comply with CEC 70, "Emergency System" signals for ground fault.
   1. Indicate ground fault with other engine generator alarm indications.
   2. Trip generator protective device on ground fault.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.
B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
C. Electrical Insulation: Class H or Class F.
D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide 12-lead alternator.
E. Range: Provide broad range of output voltage by adjusting the excitation level.
F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
G. Enclosure: Dripproof.
H. Instrument Transformers: Mounted within generator enclosure.
I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.
   1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
   2. Maintain voltage within 30 percent on one step, full load.
   3. Provide anti-hunt provision to stabilize voltage.
   4. Maintain frequency within 10 percent and stabilize at rated frequency within two seconds.
J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
L. Subtransient Reactance: 12 percent, maximum.

2.9 OUTDOOR ENGINE GENERATOR ENCLOSURE

A. Description: Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components
requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

1. Sound Attenuation Level: 25dB.

B. Description: Prefabricated or pre-engineered, galvanized-steel-clad, integral structural-steel-framed, walk-in enclosure, erected on concrete foundation.

C. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads of up to 115 mph. Equipment anchorage is not a deferred submittal nor a delegated design item. Refer to details on drawings for anchorage requirements.

D. Seismic Design: Comply with seismic requirements in Section 26.05.48.16 "Seismic Controls for Electrical Systems."

E. Fire Protection: Provide fire protection according to Section 26.05.48.16. Provide smoke detector in enclosure; mounted according to NFPA 72.

F. Hinged Doors: With padlocking provisions.

G. Space Heater: Thermostatically controlled and sized to prevent condensation.

H. Lighting: Provide weather-resistant LED lighting with 50-fc average maintained.

I. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.

J. Muffler Location: Within enclosure.

K. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
3. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.

L. Interior Lights with Switch: Factory-wired, vapor-proof luminaires within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.
2. DC lighting system for operation when remote source and generator are both unavailable.

M. Convenience Outlets: Factory-wired GFCI. Arrange for external electrical connection.

2.10 VIBRATION ISOLATION DEVICES

A. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient, vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch-thick,
elastomeric isolator pad attached to baseplate underside; and adjustable equipment-
mounting and -leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

B. Comply with requirements in Section 23 21 16 "Hydronic Piping Specialties" for vibration isolation and flexible connector materials for steel piping.

C. Comply with requirements in Section 23 31 00 "HVAC Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

D. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.11 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.12 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
2. Test generator, exciter, and voltage regulator as a unit.
3. Full-load run.
4. Maximum power.
5. Voltage regulation.
6. Transient and steady-state governing.
8. Safety shutdown.
9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
10. Report factory test results within 10 days of completion of test.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

C. Do not deliver or install packaged engine generator until all permits for construction have been submitted and approved by Authority Having Jurisdiction.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Construction Manager no fewer than two working days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Owner's written permission.

3.3 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:
   1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."
   2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
   3. Install packaged engine generator with restrained spring isolators having a minimum deflection of 1 inch on 4-inch-high concrete base. Secure enclosure to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.
1. Piping materials and installation requirements are specified in Section 23 21 13 "Hydronic Piping."
2. Install flexible connectors and steel piping materials according to requirements in Section 23 21 16 "Hydronic Piping Specialties."
3. Insulate muffler/silencer and exhaust system components according to requirements in Section 23 07 16 "HVAC Insulation."
4. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches of clearance from combustibles.

F. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.
1. Piping materials and installation requirements are specified in Section 23 21 13 "Hydronic Piping."
2. Drain piping valves, connectors, and installation requirements are specified in Section 23 21 16 "Hydronic Piping Specialties."

G. Fuel Piping:
1. Copper and galvanized steel shall not be used in the fuel-oil piping system.

H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.

C. Connect cooling-system water piping to engine generator and with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Connect fuel piping to engines with a gate valve and union and flexible connector.
   1. Additional requirements for diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems.

F. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.
3.5 IDENTIFICATION

A. Identify system components according to Section 23 05 53 "Identification for HVAC Piping and Equipment" and Section 26 05 53 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL2

A. Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Perform tests recommended by manufacturer and in "Visual and Mechanical Inspection" and "Electrical and Mechanical Tests" subparagraphs below, as specified in the NETA ATS. Certify compliance with test parameters.
   
a. Visual and Mechanical Inspection:
      1) Compare equipment nameplate data with Drawings and the Specifications.
      2) Inspect physical and mechanical condition.
      3) Inspect anchorage, alignment, and grounding.
      4) Verify that the unit is clean.
   
b. Electrical and Mechanical Tests:
      1) Perform insulation-resistance tests according to IEEE 43.
         a) Machines Larger Than 200 hp: Test duration shall be 10 minutes. Calculate polarization index.
         b) Machines 200 hp or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.
      2) Test protective relay devices.
      3) Verify phase rotation, phasing, and synchronized operation as required by the application.
      4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
      5) Conduct performance test according to NFPA 110.
      6) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test. Submit documentation verifying successful completion of load test with building load, or other loads to simulate the intended load, shall be continued for a minimum time required 2 hours maximum, observing and recording load changes and the resultant effect on voltage and frequency.

3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
3.7 MAINTENANCE SERVICE

A. Engage a vendor-authorized service representative to perform maintenance service to the engine generator equipment.

B. All electrical protective relays and circuit breakers shall be set to the values recommended by the manufacturer or to the values specified in the drawings/contracts.

C. Engage a vendor-authorized service representative to perform maintenance service to the engine generator equipment.

D. Engage a vendor-authorized service representative to perform maintenance service to the engine generator equipment.

3.8 DEMONSTRATION

A. Engage a vendor-authorized service representative to perform maintenance service to the engine generator equipment.

B. Engage a vendor-authorized service representative to perform maintenance service to the engine generator equipment.

C. Engage a vendor-authorized service representative to perform maintenance service to the engine generator equipment.

D. Engage a vendor-authorized service representative to perform maintenance service to the engine generator equipment.

END OF SECTION

C-4016 New Science Building – DSA Backcheck

Contra Costa Community College District

Contra Costa Community College District

Contra Costa Community College District

Contra Costa Community College District

Contra Costa Community College District

Contra Costa Community College District

Contra Costa Community College District

Contra Costa Community College District

Contra Costa Community College District

Contra Costa Community College District

Contra Costa Community College District
SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes automatic transfer switches rated 600 V and less, including the following:
   1. Bypass/isolation switches.
   2. Remote annunciator system.
   3. Remote annunciator and control system.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
   2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

B. Shop Drawings:
   1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
   2. Include material lists for each switch specified.
   3. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
   4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Data: Certificates, for transfer switches, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Coordination
1. Provide ¼” scale drawing demonstrating that installation has been coordinated with work of other trades. Use actual dimensions from approved equipment submittals to coordinate layout and installation of transfer switches and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

2. Coordinate installation of wall-mounting and structure-hanging supports with actual transfer switch provided.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01785 "Operation and Maintenance Data," include the following:
   a. Features and operating sequences, both automatic and manual.
   b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications:

1. Member Company of NETA.
   a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Owner's written permission.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NEMA ICS 1.

C. Comply with NFPA 110.

D. Comply with UL 1008 unless requirements of these Specifications are stricter.

E. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

F. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
   1. Short-time withstand capability for three cycles.

G. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

H. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

I. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

J. Neutral Switching: Where four-pole switches are indicated, provide overlapping neutral contacts.

K. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

L. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable shrinkable sleeve markers at terminations. Color-coding and wire and cable markers are specified in Section 26 05 53 "Identification for Electrical Systems."
   1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
   2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
   3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
   4. Accessible via front access.
2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ASCO
   2. Eaton.
   3. Emerson.
   4. GE Zenith Controls.
   5. Russelectric, Inc.

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
   1. Switch Action: Double throw; mechanically held in both directions.
   2. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
   3. Conductor Connectors: Suitable for use with conductor material and sizes.
   5. Main and Neutral Lugs: Compression type.
   7. Connectors shall be marked for conductor size and type according to UL 1008.

D. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.
   1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
   2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
   3. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.

E. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

F. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

G. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

H. Automatic Transfer-Switch Controller Features:
   1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal and Alternate Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.

3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.

5. Test Switch: Simulate normal-source failure.

6. Switch-Position Pilot Lights: Indicate source to which load is connected.

   a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.

11. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
   a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
   b. Push-button programming control with digital display of settings.
   c. Integral battery operation of time switch when normal control power is unavailable.

I. Large-Motor-Load Power Transfer:

1. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be through wiring external to automatic transfer switch. Provide adjustable time delay between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.

2. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.
2.3 TRANSFER SWITCH ACCESSORIES

A. Bypass/Isolation Switches:
   1. Source Limitations: Same manufacturer as transfer switch in which installed.
   2. Comply with requirements for Level 1 equipment according to NFPA 110.
   3. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
      a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
      b. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
      c. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
      d. Transition: Provide closed-transition operation when transferring from main transfer switch to bypass/isolation switch on the same power source.
      e. Transition: Provide open-transition operation when transferring between power sources.
      f. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
      g. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
      h. Automatic and Nonautomatic Control: Automatic transfer-switch controller shall also control the bypass/isolation switch.
      i. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
      j. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
   4. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

B. Remote Annunciator System:
   1. Source Limitations: Same manufacturer as transfer switch in which installed.
   2. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches.
   3. Annunciation panel display shall include the following indicators:
      a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
      b. Switch position.
      c. Switch in test mode.
      d. Failure of communication link.
      a. Indicating Lights: Grouped for each transfer switch monitored.
      b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
      c. Mounting: Flush, modular, steel cabinet unless otherwise indicated.
d. Lamp Test: Push-to-test or lamp-test switch on front panel.

C. Remote Annunciator and Control System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Include the following functions for indicated transfer switches:
   a. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
   b. Indication of switch position.
   c. Indication of switch in test mode.
   d. Indication of failure of digital communication link.
   e. Key-switch or user-code access to control functions of panel.
   f. Control of switch-test initiation.
   g. Control of time-delay bypass for transfer to normal source.

3. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically shall revert to standalone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.

4. Remote Annunciation and Control Panel: Solid-state components. Include the following features:
   a. Controls and indicating lights grouped together for each transfer switch.
   b. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
   c. Digital Communication Capability: Matched to that of transfer switches supervised.
   d. Mounting: Flush, modular, steel cabinet unless otherwise indicated.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency systems. Include results of test for the following conditions:
   a. Overvoltage.
   b. Undervoltage.
   c. Loss of supply voltage.
   d. Reduction of supply voltage.
   e. Alternative supply voltage or frequency is at minimum acceptable values.
   f. Temperature rise.
   g. Dielectric voltage-withstand; before and after short-circuit test.
   h. Overload.
   i. Contact opening.
   j. Endurance.
   k. Short circuit.
   l. Short-time current capability.
   m. Receptacle withstand capability.
   n. Insulating base and supports damage.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.
   1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."
   2. Comply with requirements for seismic control devices specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."
   4. Provide workspace and clearances required by CEC 70.

B. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.

C. Identify components according to Section 26 05 53 "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

E. Comply with NECA 1.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

C. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

E. Route and brace conductors according to manufacturer's written instructions. Do not obscure manufacturer's markings and labels.

F. Brace and support equipment according to Section 26 05 48.16 "Seismic Controls for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing equipment, test for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with Drawings and Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, grounding, and required clearances.
   d. Verify that the unit is clean.
   e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
   f. Verify that manual transfer warnings are attached and visible.
   g. Verify tightness of all control connections.
   h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
   i. Perform manual transfer operation.
   j. Verify positive mechanical interlocking between normal and alternate sources.
   k. Perform visual and mechanical inspection of surge arresters.
   l. Inspect control power transformers.
      1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
      2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
      3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

3. Electrical Tests:
   a. Perform insulation-resistance tests on all control wiring with respect to ground.
   b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
   c. Verify settings and operation of control devices.
   d. Calibrate and set all relays and timers.
   e. Verify phase rotation, phasing, and synchronized operation.
   f. Perform automatic transfer tests.
   g. Verify correct operation and timing of the following functions:
      1) Normal source voltage-sensing and frequency-sensing relays.
      2) Engine start sequence.
      3) Time delay on transfer.
      4) Alternative source voltage-sensing and frequency-sensing relays.
      5) Automatic transfer operation.
      6) Interlocks and limit switch function.
      7) Time delay and retransfer on normal power restoration.
      8) Engine cool-down and shutdown feature.

   a. Check for electrical continuity of circuits and for short circuits.
b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
c. Verify that manual transfer warnings are properly placed.
d. Perform manual transfer operation.

5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.
   a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
   b. Simulate loss of phase-to-ground voltage for each phase of normal source.
   c. Verify time-delay settings.
   d. Verify pickup and dropout voltages by data readout or inspection of control settings.
   e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
   f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
   g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

   a. Verify grounding connections and locations and ratings of sensors.

D. Coordinate tests with tests of generator and run them concurrently.

E. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

F. Transfer switches will be considered defective if they do not pass tests and inspections.

G. Remove and replace malfunctioning units and retest as specified above.

H. Prepare test and inspection reports.

I. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
   1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
   3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

END OF SECTION
SECTI0N 264313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.
   B. Related Requirements:
      1. Section 262413 "Switchboards" for factory-installed SPDs.
      2. Section 262416 "Panelboards" for factory-installed SPDs.

1.3 DEFINITIONS
   A. Inominal: Nominal discharge current.
   B. MCOV: Maximum continuous operating voltage.
   C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
   D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
   E. OCPD: Overcurrent protective device.
   F. SCCR: Short-circuit current rating.
   G. SPD: Surge protective device.
   H. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product.
      1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
      2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.
1.5  COORDINATION

A. Provide ¼” scale drawing demonstrating that installation has been coordinated with work of other trades. Use actual dimensions from approved equipment submittals to coordinate layout and installation of SPD with panelboard, switchgear, transformers and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.6  INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.7  CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.8  WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1  GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with CEC 70.

C. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

2.2  SERVICE ENTRANCE AND TRANSFER SWITCH SUPPRESSOR

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB USA.
3. Current Technology Inc.
4. Eaton.
5. General Electric Company.
6. Intermatic, Inc.
7. Leviton Manufacturing Co., Inc.
8. Schneider Electric USA, Inc.
10. Square D; by Schneider Electric.

B. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1 and Type 2

1. SPDs with the following features and accessories:
   a. Integral disconnect switch.
   b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
   c. Indicator light display for protection status.
   d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
   e. Surge counter.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 320 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V, 1200 V for 208Y/120 V.
3. Line to Line: 2000 V for 480Y/277 V, 1000 V for 208Y/120 V.

E. SCCR: Equal or exceed 200 kA.

F. Nominal Rating: 20 kA.

2.3 PANEL SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB USA.
3. Current Technology Inc.
4. Eaton.
5. General Electric Company.
6. Intermatic, Inc.
7. Leviton Manufacturing Co., Inc.
8. Liebert; a brand of Emerson Electric Co.
9. Schneider Electric USA, Inc.
11. Square D; by Schneider Electric.
12. SSI, an ILSCO Company.

B. SPDs: Comply with UL 1449, Type 2.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
   1. Line to Neutral: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
   2. Line to Ground: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
   3. Neutral to Ground: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.

E. SCCR: Equal or exceed 100 kA.
F. Nominal Rating: 10 kA.

2.4 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.
B. Outdoor Enclosures: NEMA 250, Type 3R.

2.5 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.
B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.
C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
D. Use crimped connectors and splices only. Wire nuts are unacceptable.
E. Wiring:
1. Power Wiring: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Controls: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
   1. Compare equipment nameplate data for compliance with Drawings and Specifications.
   2. Inspect anchorage, alignment, grounding, and clearances.
   3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Complete startup checks according to manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION
SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following types of LED luminaires:
   1. Materials.
   2. Finishes.
   3. Luminaire support.

B. Related Requirements:
   1. Section 26 09 23.02 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaires.
   4. Include emergency lighting units, including batteries and chargers.
   5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
   6. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The
adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project IES LM-80.

a. Manufacturers’ Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.
   1. Include plans, elevations, sections, and mounting and attachment details.
   2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

C. Samples: For each luminaire and for each color and texture with standard factory-applied finish.

D. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.
   1. Include Samples of luminaires and accessories involving color and finish selection.

E. Samples for Verification: For each type of luminaire.
   1. Include Samples of luminaires and accessories to verify finish selection.

F. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing laboratory providing photometric data for luminaires.

B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

C. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of luminaire.

E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
   1. Provide a list of all lamp types used on Project; use ANSI and manufacturers’ codes.
1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
   2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
   3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

D. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.
   1. Obtain Architect’s approval of luminaires in mockups before starting installations.
   2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
   3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE 7. Light fixture fastening, and bracing is not a deferred submittal nor a delegated design item. Refer to details on drawings for anchorage requirements.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.
   1. The term “withstand” means “the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event.”

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Standards:
   1. ENERGY STAR certified.
   2. California Title 24 compliant.
   3. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
   4. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
   5. UL Listing: Listed for damp location.
   6. Recessed luminaires shall comply with NEMA LE 4.
   7. User Replaceable Lamps:
      a. Bulb shape complying with ANSI C78.79.
      b. Lamp base complying with ANSI C81.61 or IEC 60061-1.

C. Lamps dimmable from 100 percent to 0 percent of maximum light output.

D. Internal driver.

2.3 MATERIALS

A. Metal Parts:
   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components shall be steel unless otherwise indicated.
   3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:
1. Tempered Fresnel glass, prismatic glass, diffuse glass, clear glass, prismatic acrylic and clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:
1. Extruded-aluminum housing and heat sink. Subject to Architect approval.
2. Clear anodized, powder-coat and painted finish. Subject to Architect approval.

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
1. Label shall include the following lamp characteristics:
   a. "USE ONLY" and include specific lamp type.
   b. Lamp diameter, shape, size, wattage, and coating.
   c. CCT and CRI for all luminaires.

2.4 METAL FINISHES

   A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.5 LUMINAIRE SUPPORT

   A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
   
   B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

   
   D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

   E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

   A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:
   1. Sized and rated for luminaire weight.
   2. Able to maintain luminaire position after cleaning and relamping.
   3. Provide support for luminaire without causing deflection of ceiling or wall.
   4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:
   1. Secured to outlet box.
   2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
   3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:
   1. Attached to structural members in walls or Attached to a minimum 20 gauge backing plate attached to wall structural members.
   2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:
   1. Ceiling mount with two 5/32-inch- diameter aircraft cable supports adjustable to 120 inches in length.
   2. Ceiling mount with pendant mount, four-point pendant mount with 5/32-inch- diameter aircraft cable supports adjustable to 120 inches in length.
   3. Ceiling mount with hook mount.

H. Suspended Luminaire Support:
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
3.6 STARTUP SERVICE

3.6.1 Operational Tests: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

3.6.2 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

3.6.3 Verifying transfer from normal power to battery power and retransfer to normal.

3.6.4 Ceiling-Grid-Mounted Luminaires:

- Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.

3.6.5 Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.6.6 Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod and wire support for suspension for each unit length of luminaire chassis, including one at each end.

3.6.7 Security Luminaires: Use emergency lighting at each building entrance, exit, stairwell, or other area where the building structure or doors to these areas are to be kept locked.

3.6.8 Adjusting and Inspecting Luminaires:

- Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.6.9 Perform the following tests and inspections:

- Luminaires will be considered defective if it does not pass operation tests and inspections.

3.6.10 Preparation of Test and Inspection Reports:

- Prepare test and inspection reports.

3.6.11 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.

3.6.12 Identifying System Components, Wiring, Cabling, and Terminals:

- Identify system components, wiring, cabling, and terminals.

- Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.6.13 Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

3.6.14 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

3.6.15 Verifying transfer from normal power to battery power and retransfer to normal.

3.6.16 Adjacent Luminaires:

- Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.6.17 Preparation of Test and Inspection Reports:

- Prepare test and inspection reports.

3.6.18 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.

3.6.19 Identifying System Components, Wiring, Cabling, and Terminals:

- Identify system components, wiring, cabling, and terminals.

- Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.6.20 Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

3.6.21 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.

3.6.22 Adjacent Luminaires:

- Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.6.23 Preparation of Test and Inspection Reports:

- Prepare test and inspection reports.

3.6.24 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.

3.6.25 Identifying System Components, Wiring, Cabling, and Terminals:

- Identify system components, wiring, cabling, and terminals.

- Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.6.26 Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

3.6.27 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.

3.6.28 Adjacent Luminaires:

- Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.6.29 Preparation of Test and Inspection Reports:

- Prepare test and inspection reports.

3.6.30 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.

3.6.31 Identifying System Components, Wiring, Cabling, and Terminals:

- Identify system components, wiring, cabling, and terminals.

- Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.6.32 Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

3.6.33 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.

3.6.34 Adjacent Luminaires:

- Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.6.35 Preparation of Test and Inspection Reports:

- Prepare test and inspection reports.

3.6.36 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.

3.6.37 Identifying System Components, Wiring, Cabling, and Terminals:

- Identify system components, wiring, cabling, and terminals.

- Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.6.38 Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

3.6.39 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.

3.6.40 Adjacent Luminaires:

- Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.6.41 Preparation of Test and Inspection Reports:

- Prepare test and inspection reports.

3.6.42 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.

3.6.43 Identifying System Components, Wiring, Cabling, and Terminals:

- Identify system components, wiring, cabling, and terminals.

- Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.6.44 Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

3.6.45 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.

3.6.46 Adjacent Luminaires:

- Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.6.47 Preparation of Test and Inspection Reports:

- Prepare test and inspection reports.

3.6.48 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.

3.6.49 Identifying System Components, Wiring, Cabling, and Terminals:

- Identify system components, wiring, cabling, and terminals.

- Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.6.50 Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

3.6.51 Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation.

- Verifying transfer from normal power to battery power and retransfer to normal.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION
SECTION 265613 - LIGHTING POLES AND STANDARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Poles and accessories for support of luminaires.
   2. Luminaire-lowering devices.

1.3 DEFINITIONS

A. EPA: Equivalent projected area.
B. Luminaire: Complete luminaire.
C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.
D. Standard: See "Pole."

1.4 ACTION SUBMITTALS

A. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device, arranged as indicated.
   1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.
   2. Include finishes for lighting poles and luminaire-supporting devices.
   3. Anchor bolts.
   4. Manufactured pole foundations.
B. Shop Drawings:
   1. Include plans, elevations, sections, and mounting and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Detail fabrication and assembly of poles and pole accessories.
   4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
   5. Anchor bolt templates keyed to specific poles and certified by manufacturer.
   6. Method and procedure of pole installation. Include manufacturer's written installations.
C. Samples: For each exposed lighting pole, standard, and luminaire-supporting device and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements according to AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations signed and sealed by a professional engineer.

B. Source quality-control reports.

C. Sample Warranty: Manufacturer's standard warranty.

D. Soil test reports

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For poles and luminaire-lowering devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01785 "Operation and Maintenance Data," include pole inspection and repair procedures.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Pole repair materials.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch deep. Do not apply tools to section of pole to be installed below finished grade.

D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

E. Retain factory-applied pole wrappings on metal poles until right before pole installation. Handle poles with web fabric straps.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of pole(s) and luminaire-lowering device(s) that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within a specified

Contra Costa Community College District
Contra Costa College
C-4016 New Science Building – DSA Backcheck
warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period.

1. Warranty Period: Five years from date of Substantial Completion.
2. Warranty Period for Corrosion Resistance: Five years from date of Substantial Completion.
3. Warranty Period for Color Retention: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Light pole design is not deferred submittal nor delegated design item. A complete design shall be provided on the construction drawings.

B. Seismic Performance: Foundation and pole shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
   2. Component Importance Factor: 1.5.

C. Structural Characteristics: Comply with AASHTO LTS-6-M.

D. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied according to AASHTO LTS-6-M.

E. Live Load: Single load of 500 lbf distributed according to AASHTO LTS-6-M.

F. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to ASCE 7-10.
   1. Basic wind speed for calculating wind load for poles 12 feet high is 115 mph.
      a. Wind Importance Factor: 1.0.

G. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.

H. Luminaire Attachment Provisions: Comply with luminaire manufacturers’ mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.2 ALUMINUM POLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American LitePole.
   2. Bridgewell Resources.
   3. Cooper Lighting, an Eaton business.
   4. E-conolight.
   5. EGS/Appleton Electric.
   6. H.E. Williams.
8. Hubbell Incorporated.
9. KIM Lighting.
10. LSI Industries.

B. Poles: Seamless, extruded structural tube complying with ASTM B 221, Alloy 6061-T6, 55 KSI minimum yield strength and tensile of 75-95 KSI, with access handhole in in pole wall.
   1. Shape: Round, tapered.
   2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Mast Arms: Aluminum Davit type, continuously welded to pole attachment plate. Material and finish same as plate.

D. Brackets for Luminaires: Detachable, cantilever, without underbrace.
   1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with stainless-steel bolts.
   2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

E. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

F. Grounding and Bonding Lugs: Bolted 1/2-inch threaded lug, complying with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

G. Fasteners: Stainless steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.
   1. Materials: Compatible with poles and standards as well as to substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.

H. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.

I. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

J. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.
   1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
   2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
   3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I clear coating of 0.018 mm or thicker), complying with AAMA 611.
   4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I integrally
colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

K. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
   a. Color: As selected by Architect from manufacturer's full range.

L. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Powder coat shall comply with AAMA 2604.
   a. Electrostatic applied powder coating; single application with a minimum 2.5- to 3.5-mils dry film thickness; cured according to manufacturer's instructions. Coat interior and exterior of pole for equal corrosion protection.
   b. Color: As selected by Architect from manufacturer's full range.

2.3 MOUNTING HARDWARE

A. Anchor Bolts: Manufactured to ASTM F 1554, Grade 55, with a minimum yield strength of 55,000 psi.
   1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.
   2. Headed rods manufacturer in diameter by manufacturer in length.
   3. Threading: Uniform National Coarse, Class 2A.

B. Nuts: ASTM A 563, Grade A, Heavy-Hex
   1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.
   2. Four nuts provided per anchor bolt, shipped with nuts pre-assembled to the anchor bolts.

C. Washers: ASTM F 436, Type 1.
   1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.
   2. Two washers provided per anchor bolt.

2.4 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.

C. Examine roughing-in for foundation and conduit to verify actual locations of installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 POLE FOUNDATION

A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123 M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 03 30 00 "Cast-in-Place Concrete."

B. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories.
   1. Baseplate: Stamped with manufacturer's name, date of production, and cable entry.

C. Anchor Bolts: Install plumb using manufacturer-supplied template, uniformly spaced.

3.3 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.
   1. Fire Hydrants and Water Piping: 60 inches.
   3. Trees: 15 feet from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in.
D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.
   1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
   2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
   3. Install base covers unless otherwise indicated.
   4. Use a short piece of 1/2-inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch-wide, unpaved gap between the pole or pole foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch below top of concrete slab.

F. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.

B. Steel Conduits: Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

3.5 GROUNDING

A. Ground Metal Poles and Support Structures: Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."
   1. Install grounding electrode for each pole unless otherwise indicated.
   2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground Nonmetallic Poles and Support Structures: Comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."
   1. Install grounding electrode for each pole.
   2. Install grounding conductor and conductor protector.
   3. Ground metallic components of pole accessories and foundation.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
3.7 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Inspect poles for nicks, mars, dents, scratches, and other damage.
2. System function tests.

END OF SECTION
IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

FIELD QUALITY CONTROL

A. Special Inspections:

1. Inspect poles for nicks, mars, dents, scratches, and other damage.

2. System function tests.

END OF SECTION
SECTION 265619 – LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
   2. Luminaire supports.
   3. Luminaire-mounted photoelectric relays.

B. Related Requirements:
   1. Section 26 09 23.02 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
   2. Section 26 56 13 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.
B. CRI: Color rendering index.
C. Fixture: See "Luminaire."
D. IP: International Protection or Ingress Protection Rating.
E. Lumen: Measured output of lamp and luminaire, or both.
F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaire.
   4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
   5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The
adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.

a. Manufacturer’s Certified Data: Photometric data certified by manufacturer’s laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

6. Wiring diagrams for power, control, and signal wiring.
7. Photoelectric relays.
8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Shop Drawings: For nonstandard or custom luminaires.
   1. Include plans, elevations, sections, and mounting and attachment details.
   2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

C. Samples: For each luminaire and for each color and texture indicated with factory-applied finish.

D. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing laboratory providing photometric data for luminaires.

B. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Product Certificates: For each type of the following:
   1. Luminaire.
   2. Photoelectric relay.
   3. Factory installed lighting control devices.

D. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

E. Source quality-control reports.

F. Sample warranty.
1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.
   1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers’ codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
   2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
   3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
   4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers’ laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

E. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

F. Mockups: For exterior luminaires, complete with power and control connections.
   1. Obtain Architect's approval of luminaires in mockups before starting installations.
   2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed work.
   3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
1.9 DELIVERY, STORAGE, AND HANDLING
A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.10 FIELD CONDITIONS
A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY
A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures, including luminaire support components.
      b. Faulty operation of luminaires and accessories.
      c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
   2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Seismic restraints for lighting is not a deferred submittal nor a delegated design item. Refer to details on drawings for anchorage requirements.
B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.
   1. The term "withstand" means “the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event.”

2.2 LUMINAIRE REQUIREMENTS
A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.
B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.
C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location.

E. Lamp base complying with ANSI C81.61 or IEC 60061-1.

F. Bulb shape complying with ANSI C79.1.

G. Lamps dimmable from 100 percent to 0 percent of maximum light output.

H. Internal driver.

I. In-line Fusing: Separate in-line fuse for each luminaire.

J. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

K. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Cooper Lighting, an Eaton business.
   3. Deco Lighting.
   4. Eaton.
   5. GE Lighting Solutions.
   6. Intelligent Illuminations, Inc.
   7. Intermatic, Inc.
   8. Lithonia Lighting; Acuity Brands Lighting, Inc.
   10. Schneider Electric USA, Inc.
   11. Siemens Building Technologies, Inc.

B. Comply with UL 773 or UL 773A.

C. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
   1. Relay with locking-type receptacle shall comply with ANSI C136.10.
   2. Adjustable window slide for adjusting on-off set points.

2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.
B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.
   3. Diffusing Specular Surfaces: 75 percent.

E. Housings:
   1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
   2. Provide filter/breather for enclosed luminaires.

F. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
   1. Label shall include the following lamp characteristics:
      a. "USE ONLY" and include specific lamp type.
      b. Lamp diameter, shape, size, wattage and coating.
      c. CCT and CRI for all luminaires.

2.5 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
   2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
   3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
   4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally...
colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.


D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As selected from manufacturer's standard catalog of colors.


c. Color: As selected by Architect from manufacturer's full range.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls, roofs, and canopy ceilings and overhang ceilings for suitable conditions where luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:
1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:
1. Attached to structural members in walls, Attached to a minimum 1/8 inch backing plate attached to wall structural members, Attached using through bolts and backing plates on either side of wall.


H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

K. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" and Section 26 05 33 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.3 BOLLARD LUMINAIRE INSTALLATION:

A. Align units for optimum directional alignment of light distribution.

1. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 03 30 00 "Cast-in-Place Concrete."

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 03 30 00 "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 26 05 33 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.
3.6 IDENTIFICATION
A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL
A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
   2. Verify operation of photoelectric controls.
C. Illumination Tests:
   1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):
      a. IES LM-5.
      b. IES LM-50.
      c. IES LM-52.
      d. IES LM-64.
      e. IES LM-72.
   2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
D. Luminaire will be considered defective if it does not pass tests and inspections.
E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION
A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

END OF SECTION
PART 1 – GENERAL

1.1 PROJECT DESCRIPTION/WORK INCLUDED

A. The selected contractor shall provide, install, train for, and support a PLANETARIUM LIGHTING TECHNOLOGY PACKAGE (PLTS) for the CCC Planetarium. Please refer to diagrammatic and schematic level drawings E.1. PL LIGHTING, E.1. PL, A.1 PL, AV1. BLOCK DRAWING, A1.CONSOLE, and TE1.PL. E.1.

B. The Planetarium takes the form of multi-use domed theater and, in addition to astronomy, is also used for general instruction/lecture and visualization by various College Departments including: Science, Engineering, and Math.

C. The lighting design is composed of the following components and functions:

1. RED, GREEN, BLUE LED COVE LIGHTING to serve as program lighting for planetarium usage. Lighting resides in 6” deep x 3” high cove trough provided by dome manufacturer. MINIMUM TOTAL LUMENS/FOOT WITH RGB AT 100% IS 280 LUMENS/FOOT. HIGHER OUTPUT IS ACCEPTABLE.

2. WHITE LIGHT LED COVE LIGHTING to serve as classroom lighting. MINIMUM LUMENS/FOOT WITH WHITE AT 100% IS 656 LUMENS/FOOT. HIGHER OUTPUT IS ACCEPTABLE. Lighting resides in 6” deep x 3” high cove trough provided by dome manufacturer. This lighting is divided into two independently controllable sections:
   a. A 90 degree section in the front of the theater as measured from center. This the section of the dome cove lighting beneath the INSET projector’s dome image.
   b. A 270 degree section as measured from center that makes up the remaining perimeter of the cove trough classroom lighting.

3. A low-profile MR-16 track lighting system per drawing E.1. PL LIGHTING attached to the dome tension ring, that lights the White Board in the front of the theater and the floor and walls of the perimeter of the theater.

4. Per drawing E.1. PL LIGHTING, a recessed in-wall RED LIGHT LED floor wash system that runs along the perimeter of the theater and around the central projector barrier. MINIMUM LUMENS/FOOT WITH RED AT 100% IS 140 LUMENS/FOOT. HIGHER OUTPUT IS ACCEPTABLE.

D. All lighting is to be dimmable and DMX 512 controllable from a lighting control computer system provided by the LED provider and said control system is located at the Control Console at the rear of the theater. This control system will also be controllable wirelessly from a touch screen device such as an IPAD from anywhere in the theater.

E. Also, Lighting systems numbers 2, 3, & 4 are to controllable from DMX 512 wall-dimmers switches located at the entrance as shown in drawing E.1. PL LIGHTING. These wall mounted dimmers and switches and their connections are to be provided by the selected electrical contractor.
F. LED Lighting design and control at Control Console is based on LED fixtures and controls provided by either of the following approved specified manufacturers:

1. ChromaCove, LLC
   7777 Wall Street, Ste. A
   Cleveland, OH 44125 USA
   Phone: +1 844-RGB-COVE (742-2683) Email: sales@chromacove.com
   URL http://www.chromacove.com
   a. Specified Products: Medium Signature RGB, Medium White, and ChromaCove Designer Controller

2. BOWEN TECHNOVATION
   7999 East 88th Street
   Indianapolis, IN 46256
   Phone: +1-317-863-0525 Email: jeffb@bowentechnovation.com
   URL: http://bowentechnovation.com
   a. Specified Products: ASTRO FX AURORA advanced RGB, ASTRO FX AURORA advanced WHITE, and ASTRO FX AURORA LIGHTING CONTROLLER.

3. Unless otherwise noted, a substituted component may be proposed and included, but only if approved in advance by the Planetarium Design Consultant and/or the Contra Costa College.

G. Track Lighting system design is based upon a JUNO low-profile MR-16 fixture:

1. Specified Product: Juno TRAC-MASTER, Avant Garde STUDIO II T291BL (black)

1.2 RELATED DOCUMENTS AND SECTIONS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

B. Division 06 sections for the construction of a custom audiovisual console for racks, cabling, wiring, devices, controls, adapters, etc. and other material and equipment required to complete the PLTS.

C. Division 26 sections for connections to fire-alarm systems, wiring, disconnect switches, and other electrical materials required to complete the PLTS.

D. Division 27 sections for communications racks, cabling, wiring, devices, adapters, etc. and other electrical materials required to complete PLTS.

1.3 GENERAL REQUIREMENTS

A. Guarantee: Furnish a written guarantee for a period of two years from date of acceptance.

B. All of the equipment in this specification shall be furnished and installed by the Authorized Factory Installer of the equipment with the most current software and firmware package available at the time of installation. At the time of Owner Acceptance of the installation, all equipment shall include any and all updated software or hardware
revisions. In addition, when the software is available in disk format, a backup copy of the most up to date revision, in disk format, shall be handed to Owner at the completion of the project.

C. Verifying Drawings and Job Conditions:
   1. Examine all project drawings and specifications to ensure full awareness of all work required under this Section.
   2. Visit the site and verify existing conditions. Where existing conditions differ from drawings, make adjustments and allowances for all necessary equipment to complete all parts of the work. Verify actual dimensions of construction contiguous with Planetarium equipment by field measurements before fabrication.
   3. Pre-installation Conferences: Conduct a minimum of one conference at the project site prior to the start of installation work. Where existing conditions differ from drawings, make adjustment and allowances for all necessary equipment to complete all parts of the work.

1.4 WORK IN COOPERATION WITH OTHER TRADES
   A. Examine the drawings and specifications and determine the work to be performed by the electrical and other trades. Provide the type and amount of audiovisual systems materials and equipment necessary to place this work in proper operation, completely wired, tested and ready for use.
   B. Confirm Low voltage conduit, boxes and power have been provided by the division 26 00 00 contractor.

1.5 TESTING AND ADJUSTMENT
   A. Upon completion of all audiovisual systems work, provide testing and demonstrating in the presence of the owner's inspector that the all audio, digital video and control parameters are as stated in the factory data sheets.
   B. Promptly repair or replace all equipment and parts discovered to be in need of correction. Then retest that part of the system and all associated components to correct the error. Perform all such replacement or repair at no additional cost to the Owner.

1.6 FINAL INSPECTION AND ACCEPTANCE
   A. After all requirements of the specifications and/or the drawings have been fully completed, representatives of the Owner will inspect the work. Provide competent personnel to demonstrate the operation of any item or system to the full satisfaction of each representative.
   B. Final acceptance of the work will be made by the Owner after receipt of approval and recommendation of acceptance from each representative.

1.7 RECORD DRAWINGS
   A. Drawings of Record: Provide and keep up-to-date, a complete record set of drawings. Keep these corrected daily and show every change from the original drawings. Keep this set of prints on the job site for use only as a record set. This shall not be construed as
authorization for your firm to make changes in the layout without Owner approval in each case.

B. Upon completion of the work, obtain a set of Contract Drawings from the General Contractor and create a record set professionally using a PDF editor. Deliver this set in PDF format as indicated in Submittals – Close-Out, below.

1.8 APPROVALS, EQUALS, SUBSTITUTIONS, ALTERNATIVES, NO KNOW EQUAL

A. Approvals: Where the words (or similar terms) “approved”, “approval”, “acceptable”, and “acceptance” are used, these refer to the requirement that acceptance by the Owner, Architect and Engineer is required.

B. Equal: Where the words (or similar terms) “equal”, “approved equal”, “equal to”, “or equal by”, “or equal” and “equivalent” are used, it shall be understood that these words are followed by the expression “in the opinion of the Owner, Architect, and Engineer.” For the purposes of specifying products, the above words shall indicate the same size, made of the same construction materials, manufactured with equivalent life expectancy, having the same aesthetic appearance/style (includes craftsmanship, physical attributes, color and finish), and the same performance.

C. Substitution: For the purposes of specifying products “substitution” shall refer to the submittal of a product not explicitly approved by the construction documents/specifications.

1. Substitutions of specified equipment shall be submitted and received by the Engineer ten days prior to the bid date for review and written approval. Regulatory Agency approval for all substitutions will be the sole responsibility of the Contractor. To receive consideration, requests for substitutions must be accompanied by documentary proof of its equality with the specified material. Documentary proof shall be in letterform and identify the specified values/materials alongside proposed equal values/materials. In addition, catalog brochures and samples, if requested, must be included in the submittal.

ONLY PRE-BID APPROVED PRODUCTS, ISSUED VIA A FORMAL BID ADDENDUM TO ALL BIDDERS, WILL BE ALLOWED ON THE PROJECT. REGARDLESS OF THE APPROVAL ON ANY SUBSTITUTION, ALL BIDS SHALL BE BASED ON THE PRODUCTS EXACTLY AS SPECIFIED. PRICING FOR EACH APPROVED SUBSTITUTION SHALL BE INCLUDED IN THE BID SUBMITTAL AS A SEPARATE LINE ITEM.

2. The Contractor warrants that substitutions proposed for specified items will fully perform the functions required.

D. Alternates/Alternatives: For the purposes of specifying products, “alternates” may be established to enable the Owner/Architect/Engineer to compare costs where alternative materials or methods might be used. An alternate price shall be submitted in addition to the base bid for consideration. If the alternate is deemed acceptable, written authorization will be issued.
E. **No Known Equal:** For the purposes of specifying products, “No Known Equal” shall mean that the Owner/Architect/Engineer is not aware of an equivalent product. The Contractor will need to submit a “Substitution” item, per the requirements listed above, if a different product is proposed to be utilized.

1.9 **SUBMITTALS – PRE-CONSTRUCTION**

A. Submit the shop drawing submittal as PDF files accompanied by Letter of Transmittal, which shall give a list of the number and dates of the drawings submitted.

B. Provide consecutively numbered drawings featuring the name of the project that indicate the name of the specific staff that checked and approved each drawing. Any drawings submitted without this approval will be rejected.

C. If the shop drawings show variations from the requirements of the Contract because of standard shop practice or other reasons, make specific mention of such variations in the Contractor’s letter of transmittal. If the substitution is accepted, the Contractor shall be responsible for proper adjustment that may be caused by the substitution. Submit samples upon request.

D. Only products listed as “Equal” within the contract documents, along with formally approved “Substitutions” will be reviewed. Products not conforming to these items will be rejected.

E. Shop drawings shall be submitted on the following but not limited to:
   1. System functional diagrams, including control system wiring
   2. Equipment locations and methods for mounting
   3. Console layout, equipment placement, etc.
   4. All other products called out on drawings that call for shop drawing submittal.

1.10 **SUBMITTALS – CLOSE-OUT**

A. Subsequent to completing preliminary testing, provide to the Construction Manager, Owner, and Planetarium consultant, a letter/report documenting the results of the preliminary tests and the documentation detailed below. The receipt of this documentation will constitute the acknowledgment that the installation is complete, that it conforms to this specification, and that it is ready to be reviewed and tested.

B. **Operation and Maintenance Manuals:** Provide all manuals as PDF files on three duplicate CD-ROM disks or USB drives, named consistently with the manufacturer’s name and the model number in separate folders for the planetarium and exhibit hall. Copy the same file and folder organization to the Owner.
   1. Provide step-by-step operating instructions for the day-to-day use of the system including power activation, connection of source devices, adjustment of volume levels, selection of sources, etc. Include illustrations and references to individual equipment manuals as necessary. Hyperlink the references to the individual operation manual files included in this submission.
   2. Organize the manual PDF files into folders by subsystem: audio, video, control, etc.
3. Equipment List: Include an Excel or other spreadsheet file listing all equipment including connectors and specialty hardware. Include columns for manufacturer, model, physical location, MAC address, IP address, if fixed or DHCP, VLAN, serial number, and cable label identification.

C. As-built drawings: Provide all as-built documentation as PDF files on the disks and online service mentioned above. In addition, provide a single copy each of the functional drawings, floor plans, and ceiling plans as laminated full-size drawing sets.

PART 2 - PRODUCTS

2.1 PLANETARIUM LIGHTING CONTROL SYSTEM

A. Objective: Provide an automated computer-based lighting control system to enhance the ease of presenting shows/lessons. System must be capable of controlling all dimmable RGB, RED, and WHITE light LED and MR-16 lighting systems with smooth transition (no flicker) from 0% to 100% and 100% to 0% levels.

B. The system should be able to control all DMX512 compatible lighting.

C. Have the ability to create and store for playback lighting cues with programmable fade rates and light levels.

D. In addition to the controller at the Planetarium Control console, system has a wireless interface touch screen interface to allow all lighting control from anywhere in the theater.

PART 3 - EXECUTION

3.1 ACCEPTANCE TESTS

A. Acceptance Test: Demonstrate each major component to function as specified.

B. Such tests may be performed on any piece of the system or individual equipment/device. If any test shows the equipment or system is defective or does not comply with the specifications, perform any remedies at your firm’s expense and pay the subsequent expenses of any required retesting.

3.2 TRAINING AND FIELD SUPPORT

A. Training: System Functionality

1. Provide a minimum of one, eight-hour day of prepared and organized training sessions (separate from full dome training sessions) for the benefit of the Owner's personnel. Demonstrate the location, wiring, operation and capabilities of each system component.

2. Develop with CCC, a training schedule to allow for training on the planetarium technology package that will allow for appropriate groups of personnel to be scheduled for training on the various subsystems. Training shall be of sufficient duration and depth and the schedule shall allow adequate time for personnel to absorb the training.
3. At minimum, include training on each component of the system.

3.3 MISCELLANEOUS PROJECT REQUIREMENTS

A. Single Point of Contact: Provide an English-proficient, single point of contact, i.e., project manager, to speak for the Contractor and to provide the following functions:
   1. Initiate and coordinate tasks with Owner’s Project Manager, and others as specified by Owner’s Project Manager.
   2. Provide day-to-day direction and on-site supervision of Contractor personnel.
   3. Ensure conformance with all Contract provisions.
   4. Participate in weekly site project meetings as needed.
   5. This individual will remain as Project Manager for the duration of the project. The Contractor may change Project Managers only with the Owner’s Project Manager’s written approval.

B. Planning meetings and schedule: Within thirty (30) calendar days after the date of award of the Contract, an initial planning meeting will be held with the successful bidder to clarify all requirements (systems, services, distribution methods, etc.), identify responsibilities, and schedule the events that will transpire during the implementation of the project. Within one week of this initial meeting, the Contractor shall provide a written report and project schedule to clearly document the events and responsibilities associated with the project.

C. Site Cleaning: Throughout the progress of the plant construction, the Contractor shall keep the working area free from debris of all types and remove from the premises all rubbish resulting from any work done by Contractor. On a daily basis and at the completion of its work, the Contractor shall, to the extent possible, leave the premises in a clean and finished condition.

D. Safety Requirements: Contractor will utilize appropriate personnel and display warning signs, signals, flags and/or barricades at the work site to ensure adherence to safety regulations and as prudence requires.

E. Specification/Drawing Status: All specifications and drawings related to this project will be “frozen” after shop drawing approval. The Owner reserves the right to negotiate any future changes with the Contractor at any time.

F. Upon approval of shop drawings, contractor shall immediately place orders for all required materials, components, and supplies. In addition, contractor shall secure and forward written confirmations (including orders and shipping dates) direct from each manufacturer/vendor to the Owner’s Project Manager.

G. Contractor shall expedite shipment of all materials, components and supplies, as necessary to ensure the successful completion of the Project by the date required. All costs for expediting shall be included within contractor’s pricing as provided below.

H. The system cost herein shall include administration/maintenance training for at least ten Owner’s representatives with a minimum allotment of sixteen (16) hours. All training shall include written and/or video materials that shall remain the property of Owner. If materials are written, they shall be provided in quantities sufficient for each person.
trained; if materials are video, one copy of each will be required. The administration/maintenance training shall include, but not be limited to, the following:

1. Review of as-built documentation, including a site demonstration.
2. All warranty information.

3.4 DAMAGES

A. The Contractor will be held responsible for any and all damages to portions of the building caused by it, its employees or sub-contractors; including but not limited to:

1. Damage to any portion of the building caused by the movement of tools, materials or equipment.
2. Damage to any component of the construction of spaces.
3. Damage to the electrical distribution system.
4. Damage to the electrical, mechanical and/or life safety or other systems caused by inappropriate operation or connections made by the Contractor or other actions of Contractor.
5. Damage to the materials, tools and / or equipment of the Owner, its consultants, agents and tenants.
6. Damage to the projection dome surface
7. Damage, interference, or outage to campus wide area or local area networks.

3.5 INSPECTIONS

A. On-going inspections shall be performed during construction by the Owner’s Project Manager. All work shall be performed in a high-quality manner and the overall appearance shall be clean, neat and orderly. The following points will be examined and must be satisfactorily complied with:

1. Are all cables properly labeled, from end-to-end?
2. Have all terminated cables been properly tested in accordance with the specifications for the specific category as well as tested for opens, shorts, polarity reversals, transposition and presence of AC and/or DC voltage?
3. Have the pathway guidelines been followed? Are all cable penetrations installed properly and fire stopped according to code?
4. Has the Contractor avoided excessive cable bending?
5. Is Cable fill correct?
6. Are terminations compatible with applications equipment?
7. Are connectors properly turned right side up in the Jack Panels or faceplates without cables wrapped or twisted?
8. Is the jacket maintained right up to the termination?
9. Are identification markings uniform, permanent and readable?

3.6 COMPLETION OF WORK

A. At the completion of the System, restore to its former condition, all aspects of the project site. On a daily basis, remove all waste and excess materials, rubbish debris, tools and equipment resulting from or used in the services provided under this Contract. Provide all clean up, restoration, and removal noted above at no cost to Owner. If the Contractor fails in its duties under this paragraph, the Owner may upon notice to the Contractor perform the necessary clean up and deduct the costs thereof from any amounts due or
to become due to the Contractor. Remove trash from work areas and bring it to the Contractor-provided dumpster.

B. Final Punch Walk: Complete a final inspection to determine if all conditions of the scope of work are completed to the owner’s satisfaction. Provide a punch list within ten days of the punch walk, unless otherwise indicated, and present it to the Contractor for completion prior to final project sign-off by the owner. If an item is missed during the punch walk or not included on the “punch list” for any reason, it does not release the Contractor from completing the scope of work as defined in the specification or drawings.

C. Contractor shall submit complete Record Documentation as outlined in submittals section prior to project sign-off by owner.

3.7 SYSTEM AND/OR NETWORK TESTING

A. Upon completion of installation, execute all of the tests listed in this specification. Provide the Owner, written notice when all such tests have been completed to Owner’s satisfaction and Manufacturer’s specifications, Contractor shall give the Owner written notice thereof.

B. Assume responsibility of assuring that the system and network interface installed operates properly, including any required coordination with other suppliers.

3 3.13 FINAL ACCEPTANCE

A. The Owner or Owner’s representative may visit the site during the installation of the system to ensure that correct installation practices are being followed.

B. Notify the Owner’s representative when the systems are ready for a final job review. The review will take place within one week after notification.

C. If need for additional adjustment becomes evident during final acceptance and/or demonstration and testing, continue adjustment until the system functions fully as designed.

D. The Owner or Owner’s representative will review the installation and certification data prior to the system acceptance.

E. The Owner or Owner's representative may test some of the system’s features to ensure that the certification data is correct. If a substantial discrepancy is found, the Owner reserves the right to have an independent consultant perform a certification of the entire system. If such a procedure is undertaken, the cost of the testing will be billed back to the Contractor.

F. In the event that repairs or adjustments are necessary, make these repairs at your firm’s expense. Complete all repairs within five days from the time they are disclosed to your firm.

END OF SECTION
SECTION 27 00 00 - BASIC COMMUNICATIONS REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes general administrative and procedural requirements for Division 27, and is intended to supplement, not supersede, the general requirements specified in Division 00.

B. The requirements described herein include the following:

1. References
2. Definitions
3. System Description and Project Conditions
4. Submittals
5. Quality Assurance
6. Delivery, Storage, and Handling
7. Scheduling
8. Warranty
9. Product Substitutions
10. Project Management and Coordination Services
11. Permits and Inspections
12. Field Quality Control
13. Project Closeout and Record Documents

C. Related Items

1. General and Supplementary Conditions: General provisions of the Prime Contract and Divisions 00 and 01 apply to Division 27.
2. Consult other Divisions and Sections, determine the extent and character of related work, and coordinate Work of Division 27 with that specified elsewhere to produce a complete and operable installation.
3. Section 27 05 26, “Communication Grounding and Bonding”
4. Section 27 05 28, “Communication Building Pathways”
5. Section 27 05 33, “Communication Building Pathways – Conduits and Boxes”
6. Section 27 05 36, “Communication Building Pathways – Cable Tray”
7. Section 27 08 11, “Communication Twisted Pair Testing”
8. Section 27 08 21, “Communication Optical Fiber Testing”
9. Section 27 11 00, “Communication Equipment Rooms”
10. Section 27 13 13, “Communication Backbone ISP Twisted Pair Cabling”
11. Section 27 13 14, “Communication Backbone OSP Twisted Pair Cabling”
12. Section 27 13 23, “Communication Backbone ISP Fiber Optic Cabling”
13. Section 27 13 24, “Communication Backbone OSP Fiber Optic Cabling”
14. Section 27 15 13, “Communication Horizontal Twisted Pair Cabling”

1.2 REFERENCES

A. General

1. Codes, standards, and industry manuals/guidelines listed by reference, including revisions by issuing authority, form a part of this specification section to extent indicated. Consider such codes and/or standards a part of this specification as though fully repeated herein.
2. Standards listed are identified by issuing authority, authority abbreviation, designation number, title or other designation established by issuing authority. Standards subsequently referenced herein are referred to by issuing authority abbreviation and standard designation.

3. Reference to codes, standards, specifications and recommendations of technical societies, trade organizations and governmental agencies shall mean that latest edition of such publications adopted and published prior to submittal of the bid unless otherwise specifically stated.

B. Codes: Perform work and furnish materials and equipment under Division 27 in accordance with applicable requirements of the latest edition of governing codes, rules and regulations including but not limited to the following minimum standards, whether statutory or not:

1. California Code of Regulations (CCR):
   a. Title 8, “Industrial Relations”
      1) Chapter 3.22, “California Occupational Safety and Health Regulations (CAL/OSHA)”
   b. Title 24, “California Building Standards Code”
      2) Part 2, “California Building Code” (CBC)
      3) Part 3, “California Electrical Code” (CEC)
      4) Part 11, “California Green Building Standards Code” (CALGeen)”

2. National Fire Protection Agency (NFPA)
   a. NFPA 75, “Protection of Information Technology Equipment”


4. Other applicable national, state, and local binding building and fire codes

C. Standards: Perform work and furnish materials and equipment under Division 27 in accordance with the latest editions of the following standards as applicable:

1. Building Industry Consulting Services International (BICSI):
   a. Telecommunications Distribution Methods Manual (TDMM)
   c. Wireless Design Reference Manual (WDRM)

2. EIA testing standards

3. National Electrical Contractors Association (NECA):

4. Telecommunications Industry Association (TIA):
   a. ANSI/TIA-568-C.0, “Generic Telecommunications Cabling for Customer Premises”
   b. ANSI/TIA-568-C.1, “Commercial Building Telecommunications Cabling Standards - Part 1 General Requirements”
   c. ANSI/TIA-568-C.2, “Balanced Twisted Pair Telecommunications Cabling and Components”
   e. ANSI/TIA-569-B, “Commercial Building Standard for Telecommunications Pathways and Spaces”
   f. ANSI/TIA/EIA-598-B, “Optical Fiber Cable Color Coding”
   g. ANSI/TIA-606-B, “Administration Standard for Telecommunications Infrastructure”
h. ANSI/TIA-607-C, “Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises”
i. ANSI/TIA-758-A, “Customer-Owned Outside Plant Telecommunications Infrastructure Standard”
j. ANSI/TIA-1005, “Telecommunications Infrastructure Standard for Industrial Premises”

5. CCCCD Infrastructure Standard
   a. Districtwide Technology Infrastructure Standard Rev. 02.60, Dated August 2018

1.3 DEFINITIONS

A. The definitions of Divisions 00 and 01 shall apply to Division 27 sections.

B. In addition to those definitions of Divisions 00 and 01, the following list of terms as used in this specification defined as follows:

1. “AFF”: Above Finished Floor
2. “As directed”: As directed or instructed by the Owner, or their authorized representative
3. “AHJ”: Authority Having Jurisdiction
4. “Cabling”: installed media ready for electronic or optical signal circuit use; a complete media connection comprised of cables, termination apparatus (patch panels, blocks, connectors), outlets, connecting media (path cord, crossconnect), labeling
5. “CBC”: California Building Code (CCR Title 24 Part 2)
6. “CCR”: California Code of Regulations
7. “CEC”: California Electrical Code (CCR Title 24 Part 3)
8. “Connect”: To install patch cords, equipment cords, crossconnect wire, etc. to complete an electronic or optical signal circuit
9. “Cord”: a length of cordage having connectors at each end. The term “Cord” is synonymous with the term “Jumper” and “Lead”
10. “Engineer”: TEECOM
11. “Furnish”: To purchase, procure, acquire, and deliver complete with related accessories
12. “General Contractor”: Successful bidder
13. “Identifier”: A unique code assigned to an element of the Telecommunications infrastructure that links it to its corresponding record
14. “Install”: To set in place, join, unite, fasten, link, attach, set up or otherwise connect together and test before turning over to the Owner, parts, items, or equipment supplied by contractor or others. Make installation complete and ready for regular operation
15. “IOR”: Inspector Of Record
16. “ISP”: Inside Plant
17. “LED”: Light Emitting Diode
18. “MSDS”: Material Safety Data Sheets
19. “NEC”: National Electrical Code (NFPA 70)
20. “NEMA”: National Electrical Manufacturers Association
22. “NIC”: Not In Contract (work or equipment)
23. “OFCI”: Owner-furnished contractor-installed; coordinate the integration of components furnished by the Owner; provide mounting hardware, cable, connectors, etc. to ensure proper integration of OFCI equipment
24. “OFE”: Owner Furnished Equipment
25. “OSP”: Outside Plant
26. “Owner”: Contra Costa College
27. “Owner’s Representative”: Critical Solutions Inc.
29. “Pigtails”: a length of cordage having connectors at one end
30. “Provide”: To furnish, transport, install, erect, connect, test and turn over to the Owner, complete and ready for regular operation

31. “UL”: Underwriters Laboratories

1.4 SYSTEM DESCRIPTION AND PROJECT CONDITIONS

A. In circumstances where the Specifications and Drawings conflict, the Drawings shall govern quantity and the Specifications shall govern quality.

1.5 SUBMITTALS

A. General: Refer to Division 01 for Submittal requirements applicable to this Section.

B. Submit required submittals to the General Contractor in the quantities and formats as required under the general contract. In the absence of requirements, provide as described in the following with reference to quantity and format.

C. Failure to comply with requirements in part or whole shall constitute grounds for rejection.

D. Resubmittals: For resubmittals, provide a cover letter with the resubmittal that lists the action taken and revisions made to each product in response to the Engineer’s submittal review comments. Lack of this actions-taken cover letter shall constitute grounds for non-review and/or rejection of resubmittal packages.

E. Submittal Description: Product Data

1. Obtain written approval from the Engineer for the product data submittal prior to materials and equipment purchase order and prior to installation.

2. Quantity and Media: Submit product data as described in Division 01. In the absence of requirements given, submit product data submittal as directed in writing either as an electronic submittal (preferred) via approved means (e.g., email, e-transmit) or as four printed submittals (not preferred).

3. Format and Organization – Electronic Submittal:

   a. File format shall be PDF, either as a single compiled PDF file or as a PDF portfolio. PDF files should be produced from original electronic media, not scans of printed media. If scans from prints are the only option, annotate electronically, not on the prints prior to scanning.

   b. Pages should be letter size (8.5” x 11”)

   c. Organize the Content in the following order:

      1) Cover
      2) Table of Contents (TOC)
      3) Statement of compliance
      4) Product information
      5) Seismic calculations (as required)

   d. Clearly and precisely indicate the submitted product and accessories by part number using an electronic annotation (arrow, rectangle, oval, etc.). Where the product data presents “part number builds”, list the exact part number of the submitted products and accessories.

   e. Add page numbers in numerical order with no gaps to each page that correctly correspond to the TOC.
4. Format and Organization – Printed Submittal:
   a. Paper shall be letter size (8.5” x 11”).
   b. Package printed submittal using a 3-ring binder, clear-front report cover, or similar.
      1) For 3-ring binders, clearly label the cover and spine of each binder with the required “Cover” information (e.g., insert the cover in the front and spine transparent pockets):
   c. Organize the content in the following order:
      1) Cover
      2) Table of Contents (TOC)
      3) Statement of compliance
      4) Product information
      5) Seismic calculations (as required)
   d. Include tabbed separators for improved navigation through the submittal.
   e. Clearly, precisely, and permanently indicate the submitted product and accessories by part number using an arrow stamp or other permanent indicator. Where the product data presents “part number builds”, indicate the exact part number of the submitted products and accessories.

5. Content:
   a. Cover: Include a cover that clearly displays the following information:
      1) Owner name
      2) Project name and address
      3) Submittal name (e.g., “Product Data Submittal for Telecommunications Equipment Rooms”)
      4) Project submittal number
      5) Contractor’s submittal number (discretionary)
      6) Submittal date; format: Month Day, Year (e.g., “January 1, 2019”)
      7) Specification section numbers included in the submittal (e.g., “Section 271100”)
      8) Contractor name and contact information
   b. Table of Contents (TOC): Include a TOC that lists materials by section number, article and paragraph number. Add a brief product description (what it is, size or color or other optional features), manufacturer and part number. List the submittal page number per product. Example heading for TOC:

<table>
<thead>
<tr>
<th>Section</th>
<th>Article</th>
<th>Paragraph</th>
<th>Description</th>
<th>Manufacturer</th>
<th>Part #</th>
<th>Page #</th>
</tr>
</thead>
</table>

   c. Statement of Compliance: Include a “Statement of Compliance” letter or memorandum on the submitter’s company letterhead from the highest ranking employee assigned to this project stating the submittal has been reviewed (quality control check) and is in full compliance with the requirements of the contract documents, and listing the submittal’s contents. Wet sign (and stamped, if applicable) the letter.
   d. Product Information: Include manufacturer’s technical data, product literature, "catalog cuts", data sheets, specifications, and block wiring diagrams (if necessary) that clearly describe the product’s characteristics, physical and dimensional information, electrical performance data, materials used in fabrication, material color and finish, and other relevant information such as test data, typical usage examples, independent test agency information, and storage requirements. Include products listed in the specifications, at a minimum. Include relevant products that will be installed, which are not listed in the specifications.
F. Submittal Description: Shop Drawings
   1. Prior to the start of work, submit shop drawings and obtain written approval from the Engineer for the shop drawings submittal.
   2. Quantity and Media: Submit shop drawings as described in Division 01. In the absence of requirements given, submit shop drawings as directed in writing either an electronic submittal (preferred) via approved means (email, e-transmit, FTP upload) or four printed and bound sets on bond.
   3. Format:
      a. Use the same sheet size as the contract drawings.
      b. Use the same title block as the contract drawings, modified to include contractor information.
      c. Text: 3/32" - 1/8" high when plotted at full size.
      d. Use identical symbols as those in the contract drawings.
      e. Screen background information.
      f. Plot system components (symbols, outlet, devices, pathways, cable routes, etc.) and text using a heavier line weight sufficient enough to stand out against background information.
      g. Scaling:
         1) Scale floor plans and reflected ceiling plans at 1/8"=1'-0" 
         2) Scale enlarged room plans at 1/4"=1'-0"
         3) Scale wall elevations at 1"=1'-0"
         4) Scale rack elevations at 1"=1'-0"

G. Submittal Description: As-Built Drawings
   1. Quantity and Media: Submit as-built drawings as described in Division 01. In the absence of requirements given, submit as-built drawings as directed in writing as electronic files via approved media (or four printed and bound sets on bond, if approved).
   2. Format:
      a. Use the same sheet size as the contract drawings.
      b. Use the same title block as the contract drawings, modified to include contractor information.
      c. Text: 3/32" - 1/8" high when plotted at full size.
      d. Use symbols identical to the symbols shown on the contract drawings.
      e. Screen background information.
      f. Plot system components (symbols, outlet, devices, pathways, cable routes, etc.) and text using a heavier line weight sufficient enough to stand out against background information.
      g. Electronic files shall be native format and plotted PDF files. The file names shall include the sheet number.

   3. Content:
      a. Submit as-built drawings that fully represent actual installed conditions and that incorporate modifications made during the course of construction.
      b. Symbols List
      c. Diagrams, such as (but not limited to) point-to-point diagrams, block diagrams, riser diagrams, line diagrams, and other diagrams that conceptually describe the system
      d. Floor Plans and Reflected Ceiling Plans: Scale plans at 1/8"=1'-0". Plans shall show:
         1) Locations and identifiers of telecommunications outlets
         2) Routes, types, sizes, and quantities of pathways (such as cable trays, conduits, hangers, and other pathways)
e. Enlarged Rooms Layouts: Applicable rooms: Entrance facilities, BDF, IDF's. Room drawings shall show:
1) Floor layouts – scaled at either 1/4"=1'-0", showing dimensioned placement of equipment cabinets/frames, rack bays, etc.
2) Overhead layouts – scaled at either 1/4"=1'-0", showing dimensioned placement of overhead cable support (e.g., cable tray, cable runway, conduit sleeves, etc.)
3) Rack elevations – scaled at 1"=1'-0", showing placement of termination apparatus and other equipment installed onto rack bays
4) Wall Elevations – scaled at 1"=1'-0", showing dimensioned placement of termination apparatus (e.g., termination/crossconnect blocks)

H. Submittal Description: Operation and Maintenance (O&M) Manual
1. Quantity and Media: Submit O&M Manual as described in Division 01. In the absence of requirements given, submit one packaged O&M Manual set.
2. Format and Organization:
   a. Include contents in a 3-ring binder with front cover and spine clear pockets for insertion of the cover information.
   b. Cover shall include the following information:
      1) Owner name
      2) Project name and address
      3) Manual name (e.g., “Operation and Maintenance Manual for Telecommunications Cabling System”)
      4) Date; format: Month Day, Year (e.g., “January 1, 2014”)
      5) Contractor name and contact information
   c. Include a ToC at the beginning that lists the contents.
   d. Include tabbed separators for improved navigation through the manual.
3. Content:
   a. Instructions on making a warranty claim during the warranty period
   b. Contact information during the warranty period
   c. Contact information beyond the warranty period for maintenance and related service
   d. As-built drawings, as described above, printed on tabloid size (17”x11”) paper and as electronic files – both native files and plotted PDF files
   e. Product catalog/technical information sheets for each component provided under applicable section (typically, this is the {or similar to} the accepted product data submittal), printed on letter size (8.5” x 11”) paper and as electronic files in PDF format
   f. Warranty certificate from the manufacturer and the contractor, printed on letter size (8.5” x 11”) paper, wet signed as applicable
   g. Manufacturer’s instructions for system or component use
   h. Instructions and requirements for proper maintenance (according to the manufacturer) and as to maintain warranty

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications
1. Five continuous years, minimum, design and manufacture of the materials and equipment specified herein.
2. Manufacturer(s) of products and equipment specified herein shall demonstrate that they have a quality assurance program in place to assure that the specifications are met. Include in the program, at a minimum, provisions for:
   a. Incoming inspection of raw materials
   b. In-process inspection and final inspection of the cable product
   c. Calibration procedures of test equipment to be used in the qualifications of the product
   d. Recall procedures in the event that out of calibration equipment is identified.

3. Conform to government standards on quality assurance for applications within these specifications.

B. Contractor Qualifications:
   1. A current, active, and valid C7 or C10 California State Contractors License
   2. Five, minimum, continuous years of experience
   3. Five, minimum, completed projects similar to scope and cost
   4. Evidence of technicians qualified for the work

C. Materials
   1. Materials, support hardware, equipment, parts comprising units, etc., shall be new, unused, without defects and of current manufacturer, materials
   2. Use specified products and applications, unless otherwise submitted and approved in writing.

D. Regulatory Requirements
   1. Work and materials shall conform to the latest rules of National Board of Fire Underwriters wherever such standards have been established and shall conform to the regulations of the State Fire Marshal, OSHA and the codes of the governing local municipalities. Work under Division 27 shall confirm to the most stringent of the applicable codes.
   2. Provide the quality identified within these specifications and drawings when codes, standards, regulations, etc. allow Work of lesser quality or extent. The contract documents address the minimum requirements for construction.

E. Drawings
   1. Follow the general layout shown on the drawings except where other work may conflict with the drawings.
   2. Drawings for the work within this division are essentially diagrammatic within the constraints of the symbology applied.
   3. The drawings do not fully represent the entire installation. Drawings indicate the general route for pathways and cables, and show general locations of outlets. The drawings might not expressly show every conduit, sleeve, hanger, etc., but a complete system is required.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Delivery
   1. Do not deliver products to the site until protected storage space is available.
   2. Coordinate materials delivery with installation schedule to minimize storage time at jobsite.
3. Deliver materials in manufacturer’s original, unopened, undamaged packaging and containers with identification labels (name of the manufacturer, product name and number, type, grade, UL classification, etc.) intact.
4. Immediately replace equipment damaged during shipping at no cost to the Owner, so as not to impact the construction schedule.

B. Storage and Protection
1. Store materials in clean, dry, ventilated space free from temperature and humidity conditions (as recommended by manufacturer) and protected from exposure to harmful weather conditions.
2. Comply with manufacturer’s storage requirements for each product. Comply with recommended procedures, precautions or remedies as described in the MSDS as applicable.
3. Maintain factory wrapping or provide a heavy canvas/plastic cover to protect units from dirt, water, construction debris, and traffic.
4. Storage outdoors covered by rainproof material is not acceptable.
5. Provide heat where required to prevent condensation or temperature related damage.

C. Handling
1. Handle materials and equipment in accordance with manufacturer’s written instructions. Handle with care to prevent damage, breakage, denting, and scoring.
2. Do not install damaged materials and equipment. Replace damaged equipment at no cost to the Owner.

1.8 SCHEDULING
A. Unless otherwise specified, the construction schedules of the Sections within Division 27 may be combined into a single, overall schedule.
B. Do not proceed without written approval from the Owner or Owner’s Representative for schedule of this Work.

1.9 PROJECT MANAGEMENT AND COORDINATION
A. Project Management and Coordination Services
1. Provide a project manager for the duration of the project to coordinate this Work with other trades. Coordination services, procedures and documentation responsibility include, but are not limited to, the items listed in this section.
2. Review of Shop Drawings Prepared by Other Subcontractors:
   a. Obtain copies of shop drawings for equipment provided by others that require telecommunication service connections or interface with work.
   b. Thoroughly review other trades’ shop drawings to confirm compliance with the service requirements contained in the Division 27 contract documents. Document discrepancies or deviations as follows:
      1) Prepare memo summarizing the discrepancy
      2) Submit a copy of the specific shop drawing, indicating via cloud, the discrepancy
   c. Prepare and maintain a shop drawing review log indicating the following information:
      1) Shop drawing number and brief description of the system/material
2) Date of the review
3) Name of the individual performing the review
4) Indication if follow-up coordination is required

3. Should existing conditions prohibit construction progress as submitted and approved, coordinate the adjusted installed locations with the other contractors (AV, electrical, etc).

B. Concurrent Installation
1. The network will be installed concurrent with the work of Division 27. Coordinate your work with the Owner’s/network integrator’s work. For example, coordinate scope and dates for rack and cabling (terminations) readiness to allow the network integrator to plan and schedule installation of the network equipment (for example, access switches).

C. Role of the Engineer
1. The Owner has retained the Engineer’s services through construction. During construction, the Engineer will work with and assist the Contractor as follows (in general):
   a. Review product data and shop drawings submittals for general compliance with the contract drawings and specifications.
   b. Provide interpretation and clarification of project contract documents
   c. Reply to (and ‘process’) relevant Requests for Information (RFIs)
   d. Review changes as they arise, and confirm that the proposed solutions maintain the intended functionality of the system.
   e. Interpret field problems for Owner, and translate between Owner and Construction Team.
   f. Review the testing procedures to confirm compliance with industry-accepted practices.
   g. Observe the work for general compliance with the contract documents and to ensure that the installation meets the design intent of the system, and report progress to the Owner.

D. Use of Electronic Drawing Files
1. Should the Contractor require the Engineer’s electronic files to produce shop drawings and/or as-built drawings, the Engineer will require the Contractor sign a file release agreement.

1.10 WARRANTY

A. As a minimum, warrant products and labor provided will, under normal use and service, be free from defects and faulty workmanship for period of 1 year from the date of acceptance. During the warranty period the entire system shall be kept in operating condition at no additional material or labor costs to the Owner. Also refer to specific sections for additional warranty requirements that supersedes the project’s minimum warranty.

B. Render service within 24 hours of system failure notification. Note deviations or improvements to this service at the time of bid and obtain written acceptance from the Owner, or Owner’s Representative.

C. Manufacturers of the major system components shall maintain a replacement parts department and provide testing equipment when needed. Provide complete replacement parts within 24 hours during the warranty period.
D. Conformance to certain government standards on quality assurance may be required for some applications outlined in these specifications.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials used shall present no environmental or toxicological hazards as defined by current industry standards and shall comply with OSHA and EPA standards, other applicable federal, state, and local laws.

B. Product numbers are subject to change by the manufacturer without notification. In the event a product number is invalid or conflicts with the written description, notify the Engineer in writing prior to ordering the material and performing installation work.

2.2 PRODUCT SUBMITTAL AT TIME OF BID

A. At the time of bid, include a list of major products in the Contract documenting the intended cabling system solution, AV equipment, etc.

2.3 SUBSTITUTIONS

A. Conform to the substitutions requirements and procedures outlined in Division 01

B. Only one substitution for each product specified will be considered.

C. Where products are noted as "or equal", a product of equivalent design, manufacture, and performance will be considered. Submit product data (product information, catalog cuts, pertinent test data, etc.) to substantiate that the product is in fact equivalent to that specified. The burden of proof that the substituted product is equivalent to the specified product rests with the Contractor. Whenever material, process or equipment is specified in accordance with an industry specification (ANSI, TIA, etc), UL rating, or other association standard, present an affidavit from the manufacturer certifying that the product complies with the particular standard specification. When requested by the Engineer, submit supporting test data to substantiate compliance.

D. Manufacturers’ names and model numbers used in conjunction with materials, processes or equipment included in the contract documents are used to establish standards of quality, utility and appearance. Materials, processes or equipment that, in the opinion of the Engineer, are equivalent in quality, utility and appearance will be approved as substitutions to that specified when "or equal" follows the manufacturers’ names or model number(s).

E. When the Engineer accepts a substitution in writing, it is with the understanding that the Contractor guarantees the substituted product, component, article, or material to be equivalent to the one specified and dimensioned to fit within the construction according to contract documents. Do not provide substituted material, processes, or equipment without written authorization from the Engineer. Assumptions on the acceptability of a proposed substitution, prior to acceptance by the Engineer, are at the sole risk of the Contractor.

F. Approved substitutions shall not relieve the Contractor of responsibilities for the proper execution of the work, or from provisions of the specifications.
G. Pay expenses, without additional charge to the Owner, in connection with substitution materials, processes and equipment, including the effect of substitution on self, subcontractor's or other Contractor's work.

PART 3 - EXECUTION

3.1 PERMITS AND INSPECTIONS

A. Obtain and pay for permits and inspections required for the work.

B. Furnish materials and execute workmanship for this work in conformance with applicable legal and code requirements.

C. Perform tests required herein, or as may be reasonably required to demonstrate conformance with the Specifications or with the requirements of legal authority having jurisdiction.

D. Arrange and pay for review/inspection from compliance officials responsible for enforcement of applicable codes and regulations to establish that the work is in compliance with requirements of reference codes indicated herein.

3.2 EXAMINATION

A. Verify existing conditions, stated under other sections, are acceptable for installation in accordance with manufacturer's instructions.

3.3 FIELD QUALITY CONTROL

A. Staffing: Provide a qualified foreman to supervise the crew performing the work and who is present at the job site at times work is being performed.

B. Construction Meetings: Participate in construction coordination meetings throughout the course of construction to review the progress and to resolve issues and conflicts. Prepare and distribute meeting agenda for telecommunication issues prior to, and meeting notes after meetings, in a format acceptable to the Owner. Publish meeting notes within 3 business days following the meeting.

C. Scheduling: Perform the work within the approved construction schedule. Keep the construction schedule current, based on the results of the construction meetings. At minimum, schedule shall document critical due dates, tasks, and milestones. Submit revised schedules for approval within 3 business days whenever there are modifications.

D. Inspection: Inspect the work after installation. Keep areas of work accessible and notify code authorities, or designated inspectors, of work completion ready for inspection. Document completion and inspection as required.

3.4 INSTALLATION

A. Complete work in a neat, high-quality manner, relative to common industry practices, and in accordance to NECA “Standard of Installation”.

Contra Costa Community College District
Contra Costa College
C-4016 New Science Building – DSA Increment 2
B. Complete work in conformance to applicable federal, state and local codes, and telephone standards.

C. Coordinate the entire installation throughout the construction team (general contractor and subcontractors).

D. Manufacturer's Instructions: Comply with manufacturer's published installation instructions, product data, product technical bulletins, product catalog, and other instructions for installation. Maintain a file on the jobsite of MSDSs for each product delivered to jobsite packaged with an MSDS.

E. Adjusting: Make changes and revisions to systems to optimize operation for final use. Make changes to systems such that defects in workmanship are corrected and completed systems pass the minimum test requirements.

F. Protection: Protect installed products and finish surfaces from damage during construction.

G. Repair/Restoration: Replace or repair work completed by others that you deface or destroy. Pay the full cost of this repair/replacement. Repair defects prior to system acceptance.

3.5 CLEANING

A. Remove temporary coverings and protection of adjacent work areas. Remove unused, excess, and left over products, debris, spills, or other excess materials. Remove installation equipment.

B. Leave finished work and adjacent surfaces in neat, clean condition with no evidence of damage.

C. Repair or replace damaged installed products.

D. Legally dispose of debris.

E. Clean installed products in accordance with manufacturer's instructions prior to Owner's, or Owner's Representative's, punch walk.

3.6 PUNCH WALKS AND PUNCH LISTS

A. Punching the Work of individual Sections of Division 27 may be combined when noted so.

B. Execute a punch walk with the Engineer and the Owner or Owner's Representative to observe Work.

C. Develop a punch list for items needing correction. Issue this punch list to Engineer.

D. Correct the Work as noted on punch list.

E. Execute follow up punch walk with the Engineer and the Owner or Owner's Representative to verify punch list items have been corrected.

3.7 SYSTEM ACCEPTANCE

A. Complete corrections (punch list items) prior to submitting acceptance certificate.
B. On completion of the acceptance test, submit system acceptance certificate to the Owner or Owner’s Representative requesting their signature and return of the certificate. Issue copies of the signed certificate back to the Owner or Owner’s Representative with copy to the Engineer.

3.8 TRAINING

A. After acceptance, schedule a time convenient with the Owner, or Owner’s Representative, for instruction in the configuration, operation, and maintenance of the system.

B. Refer to individual sections within Division 27 for additional training requirements.

END OF SECTION
SECTION 270413 - COMMON SUBMITTAL REQUIREMENTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER’S AND GENERAL CONTRACTOR’S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect’s staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:

   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.

   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.

   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect’s notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.

1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.

1. Submittal Numbering: See below.
2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition

1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on
one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications
section into two or more submittals to meet schedule or handling requirements, the
separate submittals are partial submittals. All partial submittals have the same submittal
number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together:
Individual items will not be 'broken out' for special handling. Arrange submittals
accordingly.

C. Submittal Numbering

1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For
      example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that
      section. In other words, for each section, the first submittal is 01, the second is
      02, and so on. The 2-digit number does not change for partial or re-submittals, so
      that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space,
      beginning with P1, and increasing by one for each partial submittal of that
      submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space,
      beginning with R1, and increasing by one for each re-submittal of that submittal.
      Do not include an R-Number for the initial submittal.
   e. Examples:


3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal
   Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the
   submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as
   follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements
      paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal
   Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 27 05 26 - COMMUNICATIONS GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Communications Grounding Backbone and Bonding of communications infrastructure and equipment to Communications Grounding Backbone.

B. Related Sections

1. Comply with the Related Sections requirements of Section 27 00 00.
2. Section 26 05 26, “Grounding and Bonding for electrical systems”

1.2 REFERENCES

A. Comply with the References requirements of Section 27 00 00.

B. In particular or addition to the codes and standards listed in Section 27 00 00, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:

1. NFPA 70, “National Electrical Code”, particularly the following Articles:
   a. Article 250: Grounding
   b. Article 770: Optical Fiber Cables and Raceways
   c. Article 800: Communications Systems
2. Underwriters Laboratories, Inc. (UL) UL 467: Grounding and Bonding Equipment
3. Electronic Industries Association/Telecommunication Industry Association:
4. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1.3 DEFINITIONS

A. Definitions as described in Section 27 00 00 shall apply to this section.

B. In addition to those Definitions of Section 27 00 00, the following list of terms as used in this specification defined as follows:

1. “BCT”: Bonding Conductor for Telecommunications
2. “CM” and “cmil”: Circular Millionths of an inch
3. “GE”: Grounding Equalizer Conductor
4. “MBRGB”: Main Building Reference Grounding Busbar
5. “TBB”: Telecommunications Bonding Backbone
6. “TBC”: Telecommunications Bonding Conductor
7. “TGB”: Telecommunication Grounding Busbar
8. “THHN”: Thermoplastic High Heat-resistant Nylon-coated
9. “TMGB”: Telecommunication Main Grounding Busbar

1.4 SYSTEM DESCRIPTION

A. Base Bid Work: The Work under this section includes furnishing materials, installation, and coordination through the General Contractor with other trades for a Communications Grounding Backbone and for bonding of telecommunications equipment and apparatus to the Communications Grounding Backbone.

B. Communications Grounding Backbone System: The Communications Grounding Backbone System contains grounding busbars, grounding conductors, bonding conductors, and connecting devices (including but not limited to pressure connectors, lugs, clamps, or exothermic welds). These components, upon completion of installation and testing, shall provide the means of a low impedance path to earth for unintentional and/or stray voltages or spurious signals present on telecommunications media and equipment. The Communications Grounding Backbone System will consist of the following aspects (refer to Drawings for additional information)

1. TMGB: Locate the TMGB in the BDF with the following connections:
   a. MBRGB, via BCT (refer to Drawings for wire size)
   b. Each TBB
   c. Ground bushings installed on each entrance conduit opening within the space, via TBC
   d. Overhead cable tray within the space, via TBC
   e. Dedicated power panel’s ACEG within the space serving communication equipment, via TBC
   f. Metallic pathways (conduits, surface raceway, etc.) within the space, via TBC

2. TBB: TBB(s) are the primary bonding conductor between the TMGB and other TGBs provided throughout a single building. The length of TBBs shall not exceed 500 feet. The TBB shall route from the MDF through each of the IDF's bonding each of the TGBs to the TMGB. Maintain TBB continuity and do not break continuity in order to bond to a TGB.

3. TGB: Locate the TGB in each IDF with the following connections:
   a. TBB
   b. Building steel, via TBC
   c. Each entrance conduit into the space, via TBC and ground bushings
   d. Overhead cable tray within the space, via TBC
   e. Panelboard’s ACEG within the space serving telecommunication equipment, via TBC
   f. Metallic pathways (conduits, surface raceway, etc.) within the space, via TBC

C. Performance Criteria for the Grounding Backbone:
   1. Resistance from any point of the communication grounding backbone system to the ground electrode and to earth shall not exceed 20 Ohms.
   2. Field test resistance and document, both electronically and printed, measured values.

D. Bonding: Bonding consists of TBCs within telecommunications rooms from the TMGB and TGBs to the following components:
   1. Rack bay
   2. Overhead cable support and vertical cable support
   3. Wall-mounted termination equipment
4. Conduit ground bushings
5. Exit pathways
6. Bonding jumpers between basket tray, cable runway, and cable tray joints & splices, and between basket tray/cable runway/cable tray and equipment racks

E. Conductor Gauge Criteria:
1. Size TBB, GE, and TBCs as 6 AWG minimum, then as 2,000 cmil per linear foot up to 3/0 AWG.

1.5 SUBMITTALS

A. Comply with Submittal procedural, quantity, and format requirements of Section 27 00 00.

B. Submittal Requirements at Start Of Construction:
1. Product Data Submittal
2. Shop Drawing Submittal(s), if the Contractor’s installation intent differs from the Contract Documents or the design intent

C. Substitutions
1. Requests for substitutions shall conform to the general requirements and procedure outlined in Section 27 00 00.

D. Submittal Requirements at Closeout: Submit to the Owner at the time of project closeout the following and before certificate of final payment is issued.
2. As-Built Drawings, consisting primarily of the Communications Grounding Backbone (not necessarily each bonded component or apparatus)

1.6 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of Section 27 00 00.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with Delivery, Storage and Handling requirements of Section 27 00 00.

1.8 WARRANTY

A. Warrant Work to perform as described within this Section for a period of 1 year. Correct deficiencies within 24 hours of notification.
PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

A. Application: Suitable for indoor installation as a BCT, TBB, GE, and/or TBC.

B. Type: THHN (or THWN)

C. Approvals:
   1. UL 83 as Type THHN

D. Conductor: soft drawn annealed copper, stranded

E. Gauge: Refer to System Description for conductor sizing criteria.

F. Insulation: PVC, high-heat and moisture resistant

G. Jacket: Nylon, abrasion, moisture, gasoline and oil resistant

H. Color: green

I. Flame Resistance: Meet the flame resistance requirements of IEEE 383, CSA FT-4 and UL VW-1.

2.2 CONNECTOR – “PARALLEL” TAP

A. Application: H-type thick wall compression tap, for making conductor-to-conductor (e.g., TBB-to-TBC) permanent connection (pigtailling, tapping, or splicing). Connectors shall be UL Listed.

B. Manufacturers:
   1. Panduit
      a. #HTCT2-2-1; “H-type” compression tap, run = #6-#2, tap = #2-#6.
      b. #HTCT250-2-1; “H-type” compression tap, run = #2-250MCM, tap = #6-#2

   2. Or equal

2.3 CONNECTOR – “C” TAP

A. Application: C-type copper thick wall compression tap, for making conductor-to-conductor (e.g., TBB-to-TBC) permanent connection (pigtailling, tapping, or splicing). Connectors shall be UL Listed.

B. Manufacturer:
   1. Panduit
      a. #CTAPF4-12-C; CTAP for #6 AWG run—to— #6 AWG tap
      b. #CTAPF2-12-C; CTAP for #2 AWG run—to— #6 AWG tap
      c. #CTAPF1/0-12-L; CTAP for 1/0 AWG run—to— #6 AWG tap
      d. #CTAPF2/0-12-Q; CTAP for 2/0 AWG run—to— #6 AWG tap
e.  #CTAPF3/0-12-Q; CTAP for 3/0 AWG run –to– #6 AWG tap

2.  Or equal

2.4  GROUNDING BUSBAR

A.  General:  Busbar shall be UL listed.

B.  Standards:  Compliant to ANSI/TIA-607-C

C.  Material:  Solid copper

D.  Holes:  Predrilled, compatible with standard NEMA bolt hole sizing and spacing and with ANSI/TIA-607-C recommendations for 2-hole lugs.

E.  Mounting:  Wall-mounted with standoffs.  Standoffs shall insulate busbar from the mounting substrate.

F.  Manufacturer:
   1.  Chatsworth Products Inc
      a.  #13622-020; busbar, 20”L x 4”W x ¼”T, TMGB hole pattern
      b.  #40153-012; busbar, 12”L x 4”W x ¼”T, TMGB hole pattern
      c.  #13622-012; busbar, 12”L x 2”W x ¼”T, TGB hole pattern
      d.  #13622-010; busbar, 10”L x 2”W x ¼”T, TGB hole pattern
   2.  Or equal

2.5  CONNECTION TO STRUCTURAL STEEL

A.  Application:  Exothermic welds shall be used for cable-to-cable, cable-to-ground rod, and cable-to-structural steel.

B.  Manufacturers:
   1.  Cadweld
      a.  Each particular type of weld shall use a kit unique to that type of weld
   2.  Or equal

2.6  CONNECTOR – COMPRESSION LUG

A.  Application:  Conductor-to-busbar and/or –rack (or other flat surfaces) connection

B.  Type:  compression lug, standard or long barrel, two-hole (1/4 inch diameter 5/8 inch on center)

C.  Manufacturers:
   1.  Panduit
      a.  #LCC6-14JAW-L; for 6 AWG conductor
      b.  #LCC4-14ADW-L; for 4 AWG conductor
      c.  #LCC2-14AW-Q; for 2 AWG conductor
      d.  #LCC1-14AW-E; for 1 AWG conductor
2.7 CONNECTOR – SPLIT-BOLT, MECHANICAL TYPE

A. Application: Conductor-to-conductor (or other round component) connection

B. Type: split-bolt mechanical connector

C. Material: high-strength copper alloy

D. Manufacturers:
   1. Cooper B-Line
      a. #WB2GC; split bolt bonding clamp
   2. Panduit
      a. #SBC3-C; split bolt bonding clamp for #6 to #3 conductor

2.8 BONDING STRAPS

A. Cable Runway Bonding Straps
   1. Application: makes multiple sections of cable tray conductively continuous
   2. Conductor: Flexible braided straps with factory terminated connectors.
   3. Manufacturers:
      a. Chatsworth Products Inc
         1) #12061-001
      b. Cooper B-Line
         1) #SB6691x7¾
      c. OZ/Gedney
         1) Type BJ
      d. Thomas & Betts
         1) #3840 series
      e. Or equal

B. Cable Tray Bonding Straps
   1. Application: makes multiple sections of cable runway conductively continuous
   2. Conductor: Flexible braided straps with factory terminated connectors.
   3. Manufacturers:
      a. Cooper B-Line
         1) #99-N1
      b. Thomas & Betts
         1) #FB95
2.9 LABELS

A. Labels for Busbars
   1. Labels shall be machine-printable (such as by a laser printer or hand-held printer)
   2. Printable area should be approximately 2 inch wide x 0.5 inch high
   3. Printable area color shall be white
   4. Manufacturer:
      a. Panduit
         1) #C200X100FJJ; laser/ink jet labels, white – for busbars
      b. Or equal

B. Labels for Conductors
   1. Labels shall be machine-printable (such as by a laser printer or hand-held printer)
   2. Labels shall be adhesive-backed and have a self-laminating feature
   3. Printable area should be 1 inch wide x 0.5 inch high, or larger
   4. Printable area color shall be white
   5. Manufacturer:
      a. Panduit
         1) #S100X150YAJ; laser/ink jet labels, white – for #6 wires
         2) # S100X225YAJ; laser/ink jet labels, white – for #6 to #1/0 wires
      b. Or equal

2.10 MISCELLANEOUS

A. Wire Clamp
   1. Material: nylon, UV stabilized.
   2. Color: black
   3. Size: 0.25" holding diameter for 6 AWG; or size as required based on conductor size.
   4. Manufacturer:
      a. Richco Inc.
         1) #N4B-BLK
      b. Or equal

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the Execution requirements of Section 27 00 00.
B. Work shall comply with the International Building Code, International Fire Code, National Electrical Code, UL 467, and ANSI/TIA-607-C standards, as well as local codes that may specify additional grounding and/or bonding requirements. If discrepancies between codes and/or standards arise, codes shall prevail, and then the more stringent requirement shall prevail, and as directed by the AHJ.

C. Install components to manufacturer’s instructions and recommendations and as required per UL listing.

D. Identify grounding and bonding conductors and components according to local codes.

E. Terminations must be accessible for inspection and maintenance during the life of the system.

3.2 EXAMINATION AND PREPARATION

A. Prior to the start of this section’s work, examine pathways and communications rooms for completeness, compatibility with the work of this section, and readiness for connections with the work of this section.

3.3 INSTALLATION

A. BCT, TBB, and GE Conductors
   1. Install BCT and TBB conductors in conduit and in a manner to protect them from physical damage.
   2. When routing BCT and TBB conductors through metallic conduit 3 feet or longer, bond the conductor to the conduit at both ends using a #6 AWG bonding conductor as a pigtail, an irreversible connection (preferably exothermic weld) for the conductor-to-pigtail connection, and insulated ground bushings at the conduit ends.
   3. Install the BCT and TBB conductors without splices.
      a. In the event that a splice is necessary, notify the Engineer in writing. Do not proceed with splicing work until the Engineer has accepted in writing the installation of a splice.
      b. Locate the splice in a telecommunications space and ensure accessibility.
      c. Perform the splice using an exothermic weld and an irreversible compression-type connector.
   4. Where shown on the drawings, connect grounding conductors to structural steel using exothermic welds. Each particular type of weld shall use a kit unique to that type of weld.

B. TMGB and TGB Busbars
   1. Mount busbars as noted on Drawings and using insulating standoffs. If not noted on drawings, install busbars onto wall at 24 inches AFF located within 5 feet of backbone pathways or rack bay.

C. Panelboard Bonding
   1. Where a panelboard is located in the same communications room as a TMGB/TGB and serves that room, provide TBC between busbar and that panelboard’s Alternating Current Equipment Ground (ACEG) bus (where equipped) or the enclosure.
E. Bonding

1. Provide TBC and appropriate grounding hardware between the nearest TMGB/TGB and the equipment racks / rack bay, overhead cable support, vertical cable support, telecommunication conduits, primary pathways that enter/exit the room (if applicable), and other metallic telecommunication infrastructure components. Refer to Drawings for additional information.

2. Minimum size: #6. If longer than 25 feet, size TBCs based on length using 2000 cmil per foot, up to 2/0 AWG.

3. Install TBCs in a manner that will protect them from physical and mechanical damage.

4. Routing:
   a. Route TBCs in the shortest possible path, using right angles for turns and routed parallel to building lines. Route on outside edges of wall plywood. Do not cut across the middle of the plywood taking space away from other equipment or components.
   b. Utilize a minimum 1-foot bend radius.

5. Connection to TMGB/TGBs:
   a. Thoroughly clean busbars prior to attaching connectors to the busbar.
   b. Fasten connectors (e.g., lugs) to the busbar using matching size bolt, flat washer Belleville washer, and nut. Torque hardware set.

6. Rack Bay Bonding
   a. Refer to Drawings for detailed diagrammatic requirements for bonding the rack bay.
   b. Bond equipment racks, frames, frame bays, cabinets, server racks, and other similar support systems located within the same room or space as the TMGB/TGB to the busbar.
   c. Use approved connectors for TBC-to-rack, -frame, and -cabinet connections.
   d. Rack bays may be bonded in series using either of the following configurations:
      1) Series: Provide a TBC from the TGB to the rack closest to the busbar; then provide a TBC to the other racks in the rack bay in series using a common lug/connection per rack. The rack shall not be used as a ‘conductor’ in the series connection.
      2) String: Provide one ‘main’ TBC from the TGB along the length of the rack bay, and provide a pigtail from the ‘main’ TBC per rack. Use an irreversible connection (such as “C” tap) for the ‘main’-to-pigtail connection.

7. Overhead and Vertical Cable Support Bonding
   a. Bond overhead and vertical cable support located within the same room or space as the TMGB/TGB to the busbar.
   b. Provide either UL listed connectors and splice plates or UL Listed bonding strap to bond sections of overhead cable support for ground continuity. This requirement applies to runway sections and junctions within a single telecommunication room.

8. Termination Field Bonding
   a. Bond termination blocks to the TMGB/TGB within the same room or space. Termination blocks may be bonded in series, with the block closest to the TMGB/TGB bonded to the busbar. Refer to Drawings for detailed diagrammatic requirements for bonding the termination blocks.

9. Metallic Surface Raceway Bonding
   a. Bond metallic surface raceways for telecommunications cabling to approved electrical ground located within the same room or space as the surface raceway.
3.4 LABELING

A. General Requirements
1. Labeling, identifier assignment, and label colors shall conform to TIA/EIA-606-A Administration Standard and as approved by the Engineer before installation.
2. Permanently label TBCs. Affix label as close as practical to each end of the conductor.

B. Label Format
1. Provide permanent labels with machine-generated text; hand written labels will not be accepted.
2. Labels on TBCs shall fully wrap around conductors with a self-laminating feature to provide permanent marking.

C. Identifier Assignment
1. Separate label fields of the identifier with a hyphen.
2. Assign identifiers according to current practice and as approved by the Engineer before installation.
3. BCT and TBB
   a. First field: "BCT" or "TBB" (the conductor type).
   b. Second field: a unique sequential number, for example, "01".
   c. Example: "TBB-01"
4. Ground Busbars
   a. First field: "TMGB" or "TGB" (the busbar type)
   b. Second field: the room’s identity (TR identifier’s suffix) where the busbar is installed; for example, “3A2.1”.
   c. Example: “TGB-3A2.1”
5. TBC:
   a. First field: “TBC” (the bonding conductor type).
   b. Second field: The room identity where TBC exists; for example: “A1.1”.
   c. Third field: A unique sequential number; for example: “01”, “02”, etc.
   d. Fourth field: describe the device, equipment, component, or raceway being bonded.
   e. Example: “TBC-A1.1-01 (RACK BAY)”

3.5 GROUNDING BACKBONE RESISTIVITY MEASUREMENT

A. Measure ground resistance from each ground busbar to earth; record measurement. Provide additional grounding electrodes, bonding, and other elements as required to comply with resistance limits specified in this Section.

B. Submit computer-generated records of measured resistance values to Engineer for approval and for inclusion into the Operation and Maintenance Manual.

3.6 FINAL INSPECTION AND CERTIFICATION

A. Punch the Work of this Section compliant to the requirements of Section 27 00 00. Punching the Work of this Section may be combined with punching the rooms.
B. Comply with system acceptance and certification requirements of Section 27 00 00.

END OF SECTION
SECTION 27 05 28 COMMUNICATIONS BUILDING PATHWAYS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Pathway systems within buildings to support low voltage systems: namely cable hangers and rated sleeves.

B. Related Sections

1. Comply with the Related Sections paragraph of Section 270000.
2. Section 26 05 33, “Raceways and Boxes for Electrical Systems”
3. Section 27 05 33, “Communications Conduits and Boxes”
4. Section 27 05 36, “Communications Cable Trays”
5. Section 27 05 26, “Communications Grounding and Bonding”
6. Section 27 11 00, “Communication Rooms”

1.2 REFERENCES

A. Comply with the References requirements of Section 270000.

B. In additional to those codes, standards, etc., listed in 270000, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:

1. Underwriters Laboratories (UL)
   a. UL 5, “Standard for Surface Metal Raceways and Fittings”
   b. UL 5A, “Nonmetallic Surface Raceways and Fittings”
   c. UL 5C, “Standard for Surface Raceways and Fittings for Use with Data, Signal, and Control Circuits”

2. Underwriters Laboratories (UL)
   a. UL 467, “Grounding and Bonding Equipment”

1.3 DEFINITIONS

A. Definitions of Section 27 00 00 apply to this Section.

B. In addition to those Definitions of Section 27 00 00, the following list of terms as used in this Section defined as follows:

1. “Cable Hanger”: A cable support component often shaped (section view) similar to the letter J (thus gaining the nickname “J hanger”), metallic (most often steel) or non-metallic (most often thermoplastic); available in different sizes (to support different quantities of cables) and with different attachment hardware suiting multiple installation methods (e.g., wire support, beam flange clip, etc.).

2. “Cable Strap”: A flexible cable support that generally ‘wraps’ around cables and ‘latches’ into a fixed position, most often textile, available in different sizes (to support different quantities of cables) and with different attachment hardware suiting multiple installation methods (e.g., wire support, beam flange clip, etc.).

3. “Enclosure”: The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage.

4. “J Hanger” and “J Hook”: nickname for cable hanger

5. “NEC”: National Electrical Code (NFPA 70)
7. “UL”: Underwriters Laboratories

1.4 SYSTEM DESCRIPTION

A. Base Bid Work:
1. The Work of this section includes planning and coordination with General Contractor (and other trades) of inside plant pathway systems and components, furnishing necessary materials, and labor and associated services required to install pathways.

B. Cable Hanger Systems
1. Provide a complete cable hanger system compliant with requirements of the CEC (in particular, compliant with the requirements of Article 300.11), in accordance with NECA’s “Standards of Installation” (pertaining to general electrical installation practices), compliant with applicable portions of NFPA 70B, in accordance with manufacturer’s instructions, and in accordance with recognized industry practices. A “complete system” shall include cable hangers, supports, anchors, fasteners, and other required accessories.
2. Provide cable hangers between primary pathways (or telecommunications rooms) and work area pathways and/or outlet locations at intervals up to 48 inches on center per a given route, at transitions downward/upward, and within 24 inches of an outlet stub/outlet location.
3. Supports:
   a. Provide dedicated supports for cable hangers. Do not support cable hangers on ceiling grid support wires. Do not share supports with other trades. Do not support hangers from ductwork, piping, or other equipment hangers.
   b. Support Wires:
      1) Support wires shall consist of #12 drop wire (or as approved) with integral clip and fastener (such as power-actuated deck pin, beam flange, or other fastener appropriate for the use).
      2) Secure support wires at both ends in accordance with CEC.
   c. Support Rods:
      1) Support rods shall consist of 1/4 inch (6.3mm) or 3/8 inch (9.5mm) threaded or smooth rod and concrete anchor or beam flange clip or angled flange clip (as required for attachment to the building structure).

4. Clearances (minimum):
   a. From fluorescent light fixtures, or other EMI sources = 6 inches
   b. From any motor = 48 inches
   c. From flue, hot water, steam line or other non-insulated heat sources = 12 inches

C. Fire Rated Sleeves
1. Provide complete fire rated sleeve systems where shown on the drawings and where cables penetrate rated walls, in accordance with ASTM E814 (UL1479). Complete shall include sleeves, brackets, frames, plates, etc, and other required accessories necessary for a complete installation according to UL System drawings.
2. Provide complete fire rated sleeve systems equal to (or greater than) the F rating of the barrier in which the device is installed.
3. Provide a system label at each penetration instance.

D. Surface Raceway
1. Provide a complete surface raceway system in accordance with NEC Article 386 and or NEC Article 388 where required by manufacturer's installations. Complete shall include base and cover straight sections, couplers, corners, 'T' junctions, feed connectors, compartment dividers, end caps, and hardware required for a fully enclosed pathway system that fully houses and conceals cables and wires. Refer to Drawings for locations and routes.

2. Surface raceway shall be mechanically and electrically continuous. Bond surface raceway system to approved electrical ground in accordance with NEC Article 250 and ANSI/TIA-607-C. Provide bonding straps where necessary to assure electrical continuity.

3. Surface raceway shall have a minimum two inch radius control at all bend points.

4. Coordinate raceway lengths with building walls, counter, and other actual field conditions. Raceways mounted above benches and counters shall align with each end of bench or counter, within 1/16-inch tolerance.

5. Finish:
   a. Paint surface raceway system to match existing walls.
   b. Touch-up any marks, blemishes or other finish damage suffered during installation.

E. Spiral Wrap
   1. Provide spiral wrap to support and dress cables from feed pathways to the point where the cables enter the furniture system.

1.5 SUBMITTALS

A. General: Conform to Submittal requirements as described in Section 270000.

B. Quantity: Furnish quantities of each submittal as noted in Section 270000.

C. Submittal Requirements Prior to the Start of Construction:
   1. Product Data Submittal, showing product dimensions, fabrications materials, fabrication details, knockout sizes and locations, capacities, finishes, and accessories.
   2. Shop Drawings Submittal, consisting of proposed changes to pathways (routes, types, sizes, etc.) compared to the contract documents.

D. Submittal Requirements at Close Out:
   1. As-Built Drawings, showing the routes/locations, dimensions, types, sizes, quantities, etc., of pathways/pathway devices.
   2. O&M Manual, including as-builds, a parts list, repair information, and detailing ongoing maintenance requirements.

E. Substitutions
   1. Requests for substitutions shall conform to the general requirements and procedure outlined in Section 270000.

1.6 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of section 27 00 00.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with Delivery, Storage and Handling requirements of section 27 00 00.
1.8 WARRANTY

A. Comply with Warranty requirements of section 27 00 00.

PART 2 - PRODUCTS

2.1 HANGERS AND STRAPS

A. Application: Suitable for indoor installation within ceiling space for the support of communications cables.
B. Hanger shall be rated for use in air handling space.
C. Hangers shall contain a closing loop, retainer, or latch to prevent cables from falling off the hanger.
D. Manufacturer:
   1. Eaton B-Line
      a. #BCH21-W2; for drop wire installation
      b. #BCH32-W2; for drop wire installation
      c. #BCH21; for wall installation
      d. #BCH32; for wall installation
   2. Erico
      a. #CAT12 (or variation per installation method); cable hanger
      b. #CAT21 (or variation per installation method); cable hanger
      c. #CAT32 (or variation per installation method); cable hanger
      d. #CAT425 (or variation per installation method); cable strap
   3. Panduit
      a. #JMJH2-X20
   4. Or equal

2.2 DROP WIRE

A. Application: Suitable for indoor installation within ceiling space into structure above (e.g., deck or slab) for the support of cable supports such as cable hangers.
B. Listings: UL 2043, for use in air handling spaces
C. Drop wire shall be equipped with pre-mounted ceiling clip, fastening pin, and pre-tied wire. Pin shall be 7/8". Wire shall be 12 gauge.
D. Manufacturers:
   1. Hilti #CC27 X-AL-H22P8T x ft. PT (100); drop wire assembly, "x" for length
   2. Armstrong #7891
   3. Dottie #CWC
   4. Garvin Industries
   5. Oregon Wire Products
   6. Or Equal

2.3 DROP ROD

A. Application: Suitable for indoor installation within ceiling space into building structure above (e.g., deck or slab) for the support of cable supports such as cable hangers.
B. Listings: UL 2043, for use in air handling spaces
C. Zinc plated for corrosion resistance
D. Manufacturers:
   1. CEAS #01014801; “Stiffy” straight rod, 1-1/4” power-actuated pin, 48 inches (or configured as required per instance)
   2. Or equal

2.4 FIRE RATED SLEEVE
A. Application: Suitable as a sleeve for cables to pass through a full-height partition or floor, and as a through-penetration fire stop system maintaining the fire rating of the penetrated partition.
B. Sleeve system shall be tested in accordance with ASTM E 814 (ANSI/UL1479).
C. Sleeve system shall be UL Listed and shall bear a UL Classification marking.
D. Sleeve system shall match (or exceed) the partition’s/floor’s F and T rating.
E. Manufacturers:
   1. Specified Technologies Inc (STI)

2.5 SPIRAL WRAP
A. Application: Suitable for an indoor installation for the support of telecommunications cables from a feed pathway to furniture systems, or similar.
B. Material shall be flame retardant polyethylene (UL94V-0), or equivalent.
C. Color: Black.
D. Size: As required to support the given cable bundle size (e.g., 3/4” minimum).
E. Manufacturers:
   1. Panduit
   2. Or equal

PART 3 - EXECUTION

3.1 GENERAL
A. Comply with the Execution requirements of Section 270000.

3.2 EXAMINATION AND PREPARATION
A. Prior to starting the work of this section, examine areas to receive pathways systems to verify conditions are ready for work and to verify conformance with manufacturer and specification tolerances. Notify the Owner’s Representative in writing of conditions that would adversely affect the installation, or subsequent utilization, of the system. Do not proceed with installation until unsatisfactory conditions are corrected.
B. Prior to installation, plan routes and locations of pathway systems and coordinate with other trades (ductwork, plumbing, electrical raceways, wall construction, ceilings, etc.). Pathway systems shall not unnecessarily cross other trade’s work, shall not prevent removal of ceiling tiles or panels, and shall not block access to mechanical or electrical equipment. Provide offsets as required to avoid obstruction of pathway systems with other trades.
3.3 INSTALLATION

A. Hangers and Straps
1. Install hangers so they are accessible through the ceiling grid and are not blocked by other building infrastructure.
2. Install hangers above ceiling grid to result in cables sag 6 to 12 inches (150 to 300 mm), minimum, above ceiling grid. Cables shall not rest on the ceiling grid and/or ceiling tiles.
3. Where hangers have loops/retainers, close loop/retainer (latch after cable installation).

B. Fire Rated Sleeve
1. Install the sleeves in strict accordance with the UL System drawing, with the approved shop drawings, and with the equipment manufacturer’s instructions.
2. Framed Walls – Pre-Framed and Cut-In
   a. Coordinate location of penetration with other trades such as framing (wall studs), electrical (lighting), mechanical (ducts), and other trades.
   b. For cut-in instances, cut wallboard to fit rated sleeve system – no more wallboard than is necessary to fit the system.
   c. Apply the factory-supplied gasket prior to the installation of the wall plates.
   d. Secure wall plates to sleeves per the equipment manufacturer’s recommendations.
3. Affix a label at each fire sleeve location onto the wall or floor – within 2 to 3 feet. Place label in a location that will not be obscured after cables get installed through the sleeve. Label shall describe the system’s applicable ratings, such as F, T, and L ratings.

3.4 FINAL INSPECTION AND CERTIFICATION

A. Punch the Work of this Section compliant to the requirements of Section 27 00 00.
B. Comply with system acceptance and certification requirements of Section 27 00 00.

END OF SECTION
SECTION 27 05 33 COMMUNICATIONS BUILDING PATHWAYS – CONDUITS AND BOXES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Pathway systems within buildings consisting of conduit and boxes (outlet, device, pull, and other boxes) to support low voltage systems

B. Related Sections

1. Comply with the Related Sections paragraph of Section 27 00 00.
2. Section 27 05 26, “Communications Grounding and Bonding”
3. Section 27 11 00, “Communications Equipment Rooms”

1.2 REFERENCES

A. Comply with the References requirements of Section 27 00 00.

B. In addition to those codes, standards, etc., listed in 27 00 00, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:

1. American National Standards Institute (ANSI)
   a. ANSI C80.1, "Specifications for Rigid Steel Conduit, Zinc Coated"
   b. ANSI C80.3, "Specifications for Electrical Metallic Tubing"
   c. ANSI C80.6, "Electrical Intermediate Metal Conduit"

2. ASTM International
   b. ASTM A653, “Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process”

3. International Electronic Committee (IEC)
   a. ANSI/IEC 60529, “Degrees of Protection Provided by Enclosures (IP Code)”

4. National Electrical Manufacturers Association (NEMA)
   a. NEMA 250, “Enclosures for Electrical Equipment (1000 volts maximum)”
   b. NEMA FB 1, “Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable”
   c. NEMA OS 1, “Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports”
   d. NEMA OS 2, “Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports”
   e. NEMA OS 3, “Selection and Installation Guidelines for Electrical Outlet Boxes”
   f. NEMA TC 2, “Electrical Polyvinyl Chloride (PVC) Conduit”
   g. NEMA TC 3, “Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing”
   h. NEMA TC 7, “Smooth-Wall Coilable Electrical Polyethylene Conduit”

5. Underwriters Laboratories (UL)
   a. UL 1, “Flexible Metal Conduit”
b. UL 6, “Electrical Rigid Metal Conduit - Steel”
c. UL 50, “Enclosures for Electrical Equipment, Non-Environmental Considerations”
d. UL 360, “Liquid-Tight Flexible Steel Conduit”
e. UL 467, “Grounding and Bonding Equipment”
f. UL 514A, “Metal Outlet Boxes”
g. UL 514B, “Conduit, Tubing, and Cable Fittings”
h. UL 514C, “Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers”
i. UL 651, “Schedule 40 and 80 Rigid PVC Conduit”
j. UL 797, “Electrical Metallic Tubing - Steel”
k. UL 1242, “Electrical Intermediate Metal Conduit - Steel”
l. UL 2024, “Signaling, Optical Fiber and Communications Raceways and Cable Routing Assemblies”

1.3 DEFINITIONS

A. Definitions of Section 27 00 00 apply to this Section.

B. In addition to those Definitions of Section 27 00 00, the following list of terms as used in this Section defined as follows:

1. “Backbox”: A box [see "Box"] used to house cable terminations, to house devices, and to interface with cords/equipment; a backbox is installed with walls (such as within the cavities of framed walls and/or cast-in-place within concrete walls) such that the outlet/device finish (e.g., the coverplate/faceplate) is flush with the wall finish

2. “Box”: A box (often 5-sided with 1 side open) manufactured of sheet metal with welded corners, drawn metal, cast metal, or nonmetallic material (thermoplastic) in accordance with NEMA OS 1 or NEMA OS 2 and installed in accordance with NFPA 70 Article 314; available in different sizes (volumes) and modular design configurations (gangable) that may be field assembled, one to another, to accommodate multiple devices; boxes may be used as outlet boxes, device boxes, backboxes, junction boxes, or pull boxes, depending on their intended use, and handhole enclosures.

3. “CEC”: California Electrical Code (California Code of Regulations, Title 24 Part 3)

4. “Device Box”: A box [see "Box"] with provisions for attaching and housing electrical devices (switches, receptacles, or similar wiring devices) manufactured in accordance with NEMA OS 1 and NEMA OS 2 and installed in accordance with NFPA 70 Article 314; available in different sizes (volumes) and modular design configurations (gangable) that may be field assembled, one to another, to accommodate multiple devices

5. “EIMC”: Electrical Intermediate Metal Conduit – see “IMC”

6. “EMT”: Electrical Metallic Tubing type conduit, as defined in ANSI C80.3 and NFPA 70 Article 358 An unthreaded thinwall raceway, generally made of steel (ferrous) with protective coatings or aluminum (nonferrous), of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed utilizing appropriate fittings (per NEC Article 358) FMT: Flexible Metal Tubing type conduit, as defined in NFPA 70 Article 360

8. “Floor Box”: A box [see "Box"] used to house cable terminations, to house wiring devices, and to interface with cords/equipment; a floor box is a special purpose box installed with floors (such as cast-in-place within concrete) such that the box finish (e.g., the coverplate) is flush with the floor finish

9. “HDPE: High Density Polyethylene type conduit, as defined in NFPA 70 Article 353

10. “Innerduct”: A continuous cylindrical pipe fabricated of extruded thermoplastic, available in corrugated, smooth, or other wall types and in different sizes (to support different quantities of cables), generally to provide a separate pulling channel and physical protection for fiber, coaxial, and metallic cables in telecommunications and other networks, and used in multiple applications such as the following:

a. within conduit to compartmentalize or create ‘sub-ducts’
b. in cable tray to create an isolated pathway

c. by itself as a pathway system

11. “IMC”: Intermediate Metal Conduit type conduit, as defined in ANSI C80.6 and NFPA 70 Article 342

12. “Junction Box”: A box used to join different runs of raceway (such as conduit) or cables, or both, and to provide space for the connection and branching of the enclosed conductors; most boxes can be used solely as junction boxes as long as they are used with an appropriate cover and with appropriate (code-required) access

13. “MaxCell”: a textile subduct product (also, fabric innerduct)

14. “LFMC”: Liquidtight Flexible Metal Conduit type conduit, as defined in NFPA 70 Article 353

15. “Outlet Box”: A box [see “Box”] used to house cable terminations (connectors, modular jacks, receptacles, or similar wiring interfaces) and to interface with cords/equipment

16. “NEC”: National Electrical Code (NFPA 70)

17. “NEMA”: National Electrical Manufacturers Association


19. “Pull Box”: A box used in a conduit-based pathway system to allow access to and enclose conduit ends for placing cables and to house the interface between duct banks segments

20. “RMC”: Rigid Metal Conduit type conduit, as defined in NFPA 70 Article 344 and ANSI C80.1

21. “RNC”: Rigid Nonmetallic Conduit type conduit, as defined in NFPA 70 Article 352 and as manufactured to NEMA TC 2 specifications

22. “Textile Subduct”: A continuous enclosed assembly fabricated of polymer-coated nylon fabric used in conduit to compartmentalize or create ‘sub-ducts’, available in different sizes and ‘cell’ counts (to support different quantities of cables); an example of textile subduct includes “Maxcell”

23. “UL”: Underwriters Laboratories

1.4 SYSTEM DESCRIPTION

A. The scope of work of this section includes planning and coordination with General Contractor and other trades of inside plant conduit pathway systems, furnishing necessary materials, and labor and associated services required to install these pathway systems. The scope of work includes innerduct/subducting within conduit.

B. The drawings do not explicitly show on plans each and every conduit run needed for the project. Apply the guidelines described in this section and on the drawings to support the cabling described in Division 27 and shown on the low voltage drawings, and provide reasonably inferred standard conduits, fittings, and products required to complete the conduit installation to meet the design intent.

C. The scope of work includes conduit, boxes, and related construction materials that may not be expressly specified herein or expressly called out on the drawings, such as: 1- and 2-hole straps, nail straps, clamps and clamp backs, strut clamps, U-bolts, pipe hangers, clip-in and bolted hangers, bushings, ground bushings, service entrance cap/weatherhead, pull rope/tape, etc.

D. The scope of work includes basic construction materials that may not be explicitly specified herein or called out on the drawings, such as: concrete anchors, inserts, and/or expansion bolts; concrete fasteners; powder-actuated pins; construction channel/strut; threaded rod; wood fasteners (lag screws); beam clamps; purlin clips; stud box supports/brackets; floor-mount box supports; T-bar ceiling box support bar; channel-mount box supports; bonding pigtail; drywall ring (for ring & string); etc.

E. Conduit Systems, including Pull Boxes
1. Provide conduit systems in accordance with CEC (Chapter 3 and Article 250), UL listing information, manufacturer’s instructions, and compliant to local inspections and seismic restraint requirements. Conduit systems shall conform to ANSI/TIA-569-B standard and BICSI TDMM guidelines. Complete shall include all reasonably inferred conduits, fittings, connectors, couplers, straps, pull boxes, supports, etc., necessary for a complete installation to meet the intended application whether noted, indicated or specified in the Contract Documents or not. Duct bank routes and pull and junction box locations and elevations shown on the Drawings are diagrammatic in nature. Field verify route prior to installation.

2. Provide pull boxes as necessary to facilitate proper cable placement, including the following:
   a. no more than 180 degrees bend between placement points
   b. no more than 150-200 feet conduit length (depending on the total bend between end points)
   c. to meet AHJ requirements

3. Seismic Bracing: Provide seismic bracing to conduit system (duct banks, pull boxes, etc).

4. Seismic Joints: Provide seismic joints to conduit at building seismic joints. Seismic joint configurations shall be approved by a structural engineer licensed in the state of California.

5. Expansion Joints/Fittings: Provide expansion joints and/or fittings to conduit where necessary. Expansion joints/fittings shall be approved by a structural engineer licensed in the state of California.

6. Conduit systems shall be mechanically and electrically continuous throughout. Where EMT and associated fittings are used as part of equipment grounding system, provide a bonding type locknut where hub type fitting terminates into a threadless opening and provide compression ring type fittings for terminating and coupling.

7. Minimum Conduit Size: Refer to drawings. If not noted on the drawings, the minimum conduit size shall be 1.25”.

8. When cast in concrete floors and/or walls, adhere to structural design requirements. Unless otherwise noted on the drawings, the largest trade size conduits shall not exceed 1/3 the floor or wall thickness, and conduits shall be spaced a minimum of three conduit diameters apart.

9. Bend radii for conduit trade sizes 2” and larger shall be 10 times the conduit outside diameter (OD) and bend radii for conduit trade sizes smaller than 2” shall be 6 times the conduit OD.

10. Provide transition couplings where dissimilar conduit types are joined.

11. Conduit bodies or ‘condulets’ (LBs, etc.) are prohibited for telecommunications and audiovisual cables.

12. For type EMT conduits:
   a. Provide steel (preferred) zinc plated or die cast set screw (or compression fittings). For set screw fittings, provide single screw fittings (e.g., 1-screw connectors and 2-screw couplers) for 1.5” and smaller conduits and provide double screw fittings (e.g., 2-screw connectors and 4-screw couplers) for 51mm (2”) and larger conduits.
   b. When cast in concrete, embedded masonry, or installed in dry locations (as defined by CEC, provide compression fittings and couplings.
   c. When installed in damp locations (as defined by CEC), provide rain-tight type fittings and couplings.

13. When attaching to concrete ceilings, provide vibration and shock resistant bases.

14. Conduit Straps: Provide steel straps – for interior applications, provide straps without spacers

15. At conduits entering into building from outside, provide duct plugs per duct.
16. For unused conduits, provide a mechanical-type seal/cap for protection and to keep the conduit free from debris.

17. Provide a pull tape into each conduit/duct between pull points.
   a. Where boxes are exposed in damp or wet locations or located in hazardous areas, provide cast metal boxes with gasketed cast metal cover plates.
   b. Provide supports for pull (and junction) boxes independently of conduit system and directly to the structure above. Provide seismic bracing for pull boxes.

18. Labeling:
   a. Provide permanent labels on conduit ends and pull box lids.

19. Conduit Application
   a. At interior concealed or exposed applications, 4” and smaller, provide EMT type conduit, unless otherwise noted. EMT is the preferred conduit type.
   b. In cast-in-place concrete, RNC and EMT types will be allowed for telecommunications and other low voltage systems.
   c. IMC and RMC will be allowed for telecommunications and other low voltage systems with written approval from the Engineer.
   d. LFMC is allowed for telecommunications (and other low voltage systems) only for short spans requiring flexible connections. When used, upsize LFMC 1 full trade size (to allow for a derating of the fill capacity).
   e. FMC is not allowed for telecommunications (and other low voltage systems) without written approval from the Engineer.

F. Clearances (minimum):
   1. From fluorescent light fixtures, or other EMI sources = 6 inches
   2. From any motor, transformer = 48 inches
   3. From flue, hot water, steam line or other non-insulated heat sources = 12 inches
   4. No conduit and/or supports shall encroach into ceiling height, head room of walkways, and/or doorways.

G. Penetrations:
   1. When penetrating partitions and other construction assemblies, use approved methods.
   2. When penetrating concrete walls (including shear walls) and/or floors, scan the area to be penetrated and core openings using methods approved by the structural engineer and by the AHJ. Obtain written approval for locations and means when not using methods included in the contract documents.
   3. When penetrating fire rated assemblies, provide UL Classified and FM Approved fire rated systems in accordance with ASTM E814 (UL1479). Provide labels at both sides of the penetration. Refer to drawings for approved systems per application.
   4. When penetrating acoustic rated assemblies, provide sealant to fill gaps, cavities, etc, to fully seal penetration.

H. Innerduct / Subducting
   1. Provide innerduct/subducting within backbone conduits in accordance with CEC and the UL listing information.
   2. Refer to drawings for routes requiring innerduct/subducting and innerduct/subducting sizes and types.

I. Duct Plugs
   1. Provide duct plugs at conduit ends at building entrances.
2. Provide simplex plugs for each fiber optic cable within innerduct at each building entrance. Size the plug depending upon the inside diameter of the innerduct and the outside diameter of the cable.

J. Outlet Boxes
1. Provide outlet boxes and covers/rings (raised and/or flat) in accordance with CEC Article 314 and NEMA OS 3. Ground and bond metal outlet boxes in accordance with NEC Article 250, Parts I, IV, V, VI, VII, and X.
2. Provide support for outlet boxes. Outlet boxes for telecommunications and audiovisual may share a support bracket (such as a stud span bracket) with electrical outlet boxes.

K. Poke-Thrus
1. Coring: Refer to section 03 82 13 for concrete core drilling requirements.
2. Provide poke-thrus, covers, and related products in accordance with CEC Article 314 and NEMA OS 3. Bond metal devices to ground in accordance with applicable portions of CEC Article 250 (such as Parts I, IV, V, VI, VII, and X).
3. At poke-thrus shared with power service, provide separation means in accordance with CEC.

L. Floor Boxes
1. Provide floor boxes, covers, and related products in accordance with CEC Article 314 and NEMA OS 3. Bond metal boxes to ground in accordance with applicable portions of Article 250 (such as Parts I, IV, V, VI, VII, and X).
2. At floor boxes shared with power service, provide separation means in accordance with CEC.

1.5 SUBMITTALS
A. General: Conform to Submittal requirements as described in Section 27 00 00.
B. Quantity: Furnish quantities of each submittal as noted in Section 27 00 00.
C. Submittal Requirements Prior to the Start of Construction:
   1. Product Data: Submit product data showing manufacturer, part numbers, listings, fabrication materials, dimensions, capacities, finishes, knockout sizes and configuration, accessories, etc.
   2. Shop Drawings: Submit shop drawings consisting of the following:
      a. Conduit layout/routes, supports locations, support details
      b. Highlight proposed changes to pathways (routes, types, sizes, etc.) compared to the contract documents
      c. Clearance variations and/or requests for exceptions
      d. Seismic bracing details (also see “Seismic Calculations” below)
      e. Instances of penetrations through fire and smoke rated barriers, including calling out firestopping type/UL System, size, quantity, and other relevant information
D. Submittal Requirements at Close Out:
   1. As-Built Drawings, showing the routes, types, sizes, quantities, dimensions, etc., of pathways (backbone pathways, primary pathways, conduit – required; secondary such as hangers – not necessary)
   2. O&M Manual, including as-built drawings, parts list (essentially final approved product data submittal), repair information, and maintenance requirements
E. Substitutions
1. Requests for substitutions shall conform to the general requirements and procedure outlined in Section 27 00 00.

1.6 QUALITY ASSURANCE
   A. Comply with Quality Assurance requirements of section 27 00 00.
   B. CEC Compliance: Comply with CEC, as applicable to construction and installation of conduit and boxes.
   C. NFPA Compliance: Comply with NFPA 70B, "Recommended Practice for Electrical Equipment Maintenance" pertaining to conduit and boxes.

1.7 DELIVERY, STORAGE, AND HANDLING
   A. Comply with Delivery, Storage and Handling requirements of section 27 00 00.

1.8 WARRANTY
   A. Comply with Warranty requirements of section 27 00 00.

PART 2 - PRODUCTS

2.1 ELECTRICAL METALLIC TUBING (TYPE EMT) CONDUIT AND FITTINGS
   A. Application: Products and assembled system shall be suitable for indoor applications, in accordance with the NEC Article 358
   B. Type EMT Conduit:
      1. Type EMT conduit shall be formed of cold rolled strip steel, electrical-resistance welded continuously along the longitudinal seam, and zinc coated after welding. Type EMT conduit bore shall be smooth and free of blisters, nicks or other imperfections which could mar cables.
      2. Type EMT conduit shall be listed by a nationally recognized testing laboratory to UL 797, and shall bear (stamped or molded on conduit and fittings) the UL label. Markings shall be permanent. Type EMT conduit shall meet ANSI C80.3 specifications.
      3. Type EMT conduit shall be recognized as a bonding conductor per NEC Article 250.118
      4. Factory elbows and bends minimum bend radius shall be 48°.
      5. Manufacturers – Type EMT Conduit:
         a. Allied Tube and Conduit Co (Electrical Group) “E-Z Pull” EMT conduit
         b. Cal Conduit Products “CalBrite” EMT conduit
         c. Republic Conduit
         d. Western Tube and Conduit Corp
         e. Or equal
   C. Fittings for EMT:
      1. Fittings (connectors, couplers, straps, accessories, etc.) shall be listed by a nationally recognized testing laboratory to UL 514B, and shall bear the UL label (stamped or molded - such markings shall be permanent).
      2. Fittings shall be manufactured compliant to ANSI/NEMA FB 1.
3. Standard Set-Screw Fittings: fabricated of steel with zinc electro-plated finish. Die cast zinc / cast malleable iron fittings not acceptable. Set-screws shall be case-hardened steel with hex head and cup point to firmly seat in wall of conduit for positive grounding.

4. Compression Fittings: gland and ring compression type construction; fabricated of steel zinc plated or cast malleable iron; UL Listed as raintight and suitable for concrete

5. Manufacturers – Fittings for EMT
   a. Appleton Electric Co and/or O-Z Gedney (Emerson Electric Co)
   b. Thomas & Betts Corp
   c. Or equal

D. Deflection/Expansion Sleeve:
   1. Application: Deflection/expansion sleeve shall compensate for movement in any direction between two conduit ends and shall withstand occasional vibration transmitted to conduit by rotating equipment or vehicular traffic.
   2. Deflection/expansion sleeve shall be listed by a nationally recognized testing laboratory to UL 514B and UL 467, and shall bear the UL label (stamped or molded - such markings shall be permanent).
   3. Deflection/expansion sleeve shall be fabricated of an inner sleeve, bonding braid, a neoprene outer sleeve with internal flexible stainless steel braid and outer stainless steel bands, ended with couplings (for connection to conduits).
   4. Deflection/expansion sleeve shall accommodate 0.75 inch (19mm) deflection, expansion, contraction, or parallel misalignment in any direction, shall allow up to 30 degree angular deflections, and shall be raintight.
   5. Manufacturer – EMT Expansion/Deflection Sleeve:
      a. Cooper Crouse-Hinds XD series
      b. O-Z Gedney (Emerson Electric Co) DX series
      c. Or equal

E. Expansion Sleeve:
   1. Application: Expansion sleeve shall compensate for parallel movement between two conduits.
   2. Expansion sleeve shall comply with UL514.B and NEMA FB-1.
   3. Expansion sleeve shall be fabricated of an inner steel sleeve with an oversized outer sleeve sealed with slip bushings, configured such that the outer sleeve can move over the inner sleeve. Sleeve shall come equipped with internal or external bonding braid and be ended with couplers suitable to connect to conduit ends.
   4. Manufacturers – EMT Expansion Sleeve:
      a. Cooper Crouse-Hinds XJG-EMT series
      b. O-Z Gedney (Emerson Electric Co) TX series
      c. Or equal

2.2 PULL STRING

A. Application: For use with manual or power fishing systems for light duty cable or tape pulling applications

B. Description: round, woven, polypropylene line
   1. Packaged in storage container with easy, quick, and tangle-free dispensing
   2. UV resistant, and resistant to rot and mildew
   3. Low elongation

C. Manufacturers:
1. Ideal Industries Inc Powr-Fish® or Valu-Line™ poly pull line
2. Klein Tools #56110 poly pull line
3. Or equal

2.3 PULL BOXES

A. Application: For use indoors as cable placement point (pull box) for low voltage cabling and wiring within a conduit raceway system.

B. Compliances:
   1. Pull boxes shall meet the requirements of UL 50 and NEMA Type 1.
   2. Pull boxes shall be listed by a nationally recognized testing laboratory for the purpose.

C. Material and Finish:
   1. Thickness: 16 gauge, minimum
   2. Material: the following materials are acceptable for pull boxes
      a. Pre-galvanized steel (ASTM A653), then formed
      b. Mild steel formed, then hot-dipped galvanized (per ASTM A123)
      c. Mild steel formed, then painted (polyester or epoxy powder coat, meeting ASTM D1654)

D. Size: pull box size shall comply with CEC 314.28

E. Configuration: pull boxes shall --- Covers shall be secured by machine screws at 6 inches intervals.

F. Manufacturers:
   1. Cooper B-Line (Eaton)
   2. Hoffman (Pentair)
   3. Hubbell Wiegmann (SC Series enclosures, as an example)
   4. Or equal

2.4 STEEL OUTLET BOXES AND COVERS

A. Application: For use indoors as outlet box, backbox, and/or junction box of low voltage systems to house wiring, cabling, terminations, and connectors; may also house and support components.
   1. Outlet boxes shall permit access to conductors for maintenance
   2. Outlet boxes shall come with knock-outs or punch-outs for easy creation of holes to accept conduit connectors.

B. Compliances:
   1. Outlet boxes shall meet the requirements of CEC Article 314.
   2. Outlet boxes shall be listed by a nationally recognized testing laboratory to UL 514A for Class 2 and Class 3 power-limited circuits (such as data and signal) providing bonding without the use of bonding jumpers, for remote control circuits, and for telecommunications circuits in accordance with NEC Article 314.
   3. Outlet boxes shall be manufactured compliant to NEMA: FB-1 and OS-1.
   4. Outlet boxes shall be fire resistant and suitable for use in rated spaces (reference: UL Fire Resistance Directory / "Orange Book").

C. Material and Finish:
1. Material: hot rolled, pre-galvanized steel, minimum spangle, AISI C-1008
2. Thickness: CEC 314.40(B) / 0.0625in, minimum
3. Finish: G60 hot dip zinc galvanized (0.60 oz/sq ft), meeting ASTM A123, or pre-galvanized (continuous sheet galvanizing) meeting per ASTM A653
4. Finish Thickness: ~0.0005 inches

D. Square Box and Covers/Rings – 5"
1. Dimensions: 5 in square x 2.875 in deep
2. Volume: 64 in³
3. Outlet box shall come equipped with integrated cable management/slack support.
4. Manufacturers:
   a. Randl Industries
      1) #T-55017; “5 Square” outlet box, knockouts: one 1” + one 1-1/4” per side, one 1/2” per back
      2) #T-55018; “5 Square” outlet box, knockouts: one 1/2”, + one 3/4” + one 1” per side, one 1/2” per back
      3) #T-55019; “5 Square” outlet box, knockouts: one 1/2”, + two 1” per side, one 1/2” per back
      4) #T-55057; “5 Square” outlet box with side mounting bracket, knockouts: one 1” + one 1-1/4” on 3 sides, one 1/2” per back
      5) #T-55058; “5 Square” outlet box with side mounting bracket, knockouts: one 1/2”, + one 3/4” + one 1” on 3 sides, one 1/2” per back
      6) #T-55059; “5 Square” outlet box with side mounting bracket, knockouts: one 1/2”, + two 1” on 3 sides, one 1/2” per back
      7) #R-55000; blank cover for “5 Square” outlet box
      8) #N-54000; 4”-sq cover for “5 Square” outlet box, flat
      9) #N-54012; 4”-sq cover for “5 Square” outlet box, 1/2” raised
     10) #N-54058; 4”-sq cover for “5 Square” outlet box, 5/8” raised
     11) #N-54034; 4”-sq cover for “5 Square” outlet box, 3/4” raised
     12) #N-54010; 4”-sq cover for “5 Square” outlet box, 1” raised
     13) #N-54114; 4”-sq cover for “5 Square” outlet box, 1-1/4” raised
     14) #N-54112; 4”-sq cover for “5 Square” outlet box, 1-1/2” raised
     15) #D-51G000; one gang cover for “5 Square” outlet box, flat
     16) #D-51G012; one gang cover for “5 Square” outlet box, 1/2” raised
     17) #D-51G058; one gang cover for “5 Square” outlet box, 5/8” raised
     18) #D-51G034; one gang cover for “5 Square” outlet box, 3/4” raised
     19) #D-51G010; one gang cover for “5 Square” outlet box, 1” raised
     20) #D-51G114; one gang cover for “5 Square” outlet box, 1-1/4” raised
     21) #D-52G000; two gang cover for “5 Square” outlet box, flat
     22) #D-52G012; two gang cover for “5 Square” outlet box, 1/2” raised
     23) #D-52G058; two gang cover for “5 Square” outlet box, 5/8” raised
     24) #D-52G034; two gang cover for “5 Square” outlet box, 3/4” raised
     25) #D-52G010; two gang cover for “5 Square” outlet box, 1” raised
     26) #D-52G114; two gang cover for “5 Square” outlet box, 1-1/4” raised
   b. Or equal

2.5 BOX SUPPORT ACCESSORIES

A. Box accessories shall comply with UL standards and shall be listed by a nationally recognized testing laboratory.

B. Stud-Mount Single-Box Bracket
1. Erico #SGBS16A; stud-mount bracket, for 1-1/2” or 2-1/8”D box, fits 16” stud spacing
2. Erico #SGBS24A; stud-mount bracket, for 1-1/2" or 2-1/8"D box, fits 24" stud spacing
3. Garvin #BMB16218; stud-mount bracket, for 2-1/8"D box, fits 16" stud spacing
4. Garvin #BMB16350; stud-mount bracket, for 3-1/2"D box, fits 16" stud spacing
5. Garvin #BMB24218; stud-mount bracket, for 2-1/8"D box, fits 24" stud spacing
6. Garvin #BMB24350; stud-mount bracket, for 3-1/2"D box, fits 24" stud spacing
7. Garvin #BMB16SL; stud-mount bracket, 'sliding' position for 1-1/2" or 2-1/8" D box, fits 16" stud spacing
8. Garvin #BMB24SL; stud-mount bracket, 'sliding' position for 1-1/2" or 2-1/8" D box, fits 24" stud spacing
9. Raco #900; fixed stud-mount bracket, for 2-1/8"D box, fits 16" stud spacing
10. Raco #9006; fixed stud-mount bracket, for 2-1/8"D box, fits 24" stud spacing
11. Raco #9013; adjustable stud-mount bracket, for 2-1/8"D box, fits 10-3/8" to 18" stud spacing
12. Raco #9015; adjustable stud-mount bracket, for 2-1/8"D box, fits 15" to 26" stud spacing

C. Stud-Mount Multi-Box Bracket
1. Erico #RBS16; stud-mount bracket, 3 positions for 4S and/or 4-11/16"S box, fits 16" stud spacing
2. Erico #RBS24; stud-mount bracket, 4 positions for 4S and/or 4-11/16"S box, fits 24" stud spacing
3. Garvin #BMB4S3P; stud-mount bracket, 3 positions for 4S and/or 4-11/16"S box, fits 16" stud spacing
4. Raco #9002; stud-mount bracket, 3 positions for 4S and/or 4-11/16"S box, fits 16" stud spacing
5. Raco #9002; stud-mount bracket, 4 positions for 4S and/or 4-11/16"S box, fits 24" stud spacing

D. Floor-Mount Box Mounting Bracket
1. Erico #FMBS18; floor mount support bracket for box, puts box at 18.5" above wall footer
2. Garvin #KP4-12; floor mount support bracket for 4S and/or 4-11/16"S box, puts box at 12" above wall footer
3. Garvin #KP4-18; floor mount support bracket for 4S and/or 4-11/16"S box, puts box at 18" above wall footer
4. Garvin #KP4-24; floor mount support bracket for 4S and/or 4-11/16"S box, puts box at 24" above wall footer
5. Raco #9009; floor mount support bracket for 4S and/or 4-11/16"S box, puts box at 12" above wall footer
6. Raco #9010; floor mount support bracket for 4S and/or 4-11/16"S box, puts box at 18" above wall footer

E. T-Bar Bracket
1. Erico #510HD; bracket for outlet box, attaches to T-bar ceiling grid

F. T-Bar Support
1. Erico #4ACS; adapter/support for outlet box, attaches to T-bar ceiling grid

2.6 MULTI-SERVICE FLOOR BOXES

A. Application: For use indoors as a multi-service (telecommunications, audiovisual, power) outlet box to house wiring, cabling, termination, connectors, and receptacles installed within a cast concrete floor

B. Box Construction: Seam welded 14 gauge steel
C. Compliances:
   1. Floor boxes shall be listed by a nationally recognized testing laboratory to UL 514A for Class 2 and Class 3 power-limited circuits (such as data and signal) providing bonding without the use of bonding jumpers, and remote control) circuits and for telecommunications circuits in accordance with NFPA 70 Article 314 for use in tile, terrazzo, carpet, and wood covered floors.
   2. Floor box assemblies shall meet the scrub water exclusions requirements of UL 514A for use in tile, terrazzo, carpet, and wood covered floors.

D. Load Capacity: Floor box assembly (back box, cover, etc) shall be rated to 300 lbs (minimum) static load.

E. Features:
   1. Suitable for cast-in-place concrete applications
   2. 8 gangs, minimum
   3. Knock-outs (or punch-outs) for easy creation of holes to accept conduit connectors
   4. Permit access to conductors behind terminations (for maintenance)

F. Cover Finish: Coordinate with Architect

G. Manufacturers:
   1. FSR Inc.
      a. #FL-500P-2.25; c-i-p floor box, 2.25-in depth
      b. #FL-500P-3; c-i-p floor box, 3-in depth
      c. #FL-500P-4; c-i-p floor box, 4-in depth
      d. #FL-500P-6; c-i-p floor box, 6-in depth
      e. #FL-500P-8; c-i-p floor box, 8-in depth
      f. #FL-500P-10; c-i-p floor box, 10-in depth
   2. FSR Inc.
      a. #SF-PB; ‘SmartFit’ c-i-p floor box (round), 4-in diameter x 5.9-in depth
      b. #SF-DDP; sub-plate for 4” box – two decora openings
      c. #SF-2SDP; sub-plate for 4” box – one decora, one 5-20R electrical outlet, and two keystone ports
      d. #SF-IPSPS; sub-plate for 4” box – IPS interface (3 position) and one 5-20R electrical outlet
   3. Wiremold
      a. #RFB-11; c-i-p floor box, 6 in depth, 11 gangs
      b. #RFB-9; c-i-p floor box, 4 in depth, 9 gangs
      c. #RFB119CTCAL; cover for carpet floors, with carpet cut-out area, brushed aluminum
      d. #RFB119CTCBK; cover for carpet floors, with carpet cut-out area, painted black
      e. #RFB119CTCGY; cover for carpet floors, with carpet cut-out area, gray
      f. #RFB119BTCAL; cover for flush tile or carpet floors, brushed aluminum
      g. #RFB119BTCBK; cover for flush tile or carpet floors, painted black
      h. #RFB119BTCGY; cover for flush tile or carpet floors, gray
   4. Or equal

2.7 MULTI-SERVICE WALL BOXES FOR FLAT PANEL DISPLAYS

A. Application: indoor use as a multi-service (telecommunications, audiovisual, power) outlet box to house wiring, cabling, termination, connectors, and receptacles and serve a flat panel display
B. Listings: Wall boxes shall be listed by a nationally recognized testing laboratory to UL 514A.
C. Fabrication Material: Backbox: Seam welded 14 gauge steel; Cover: 1/16” steel, electro-painted
D. Outlet box shall feature capacity for the following:
   1. Power: 1 duplex receptacle, duplex or decora style
   2. Telecom/Network: 2 network jacks (refer to section 271513 for jack information)
   3. AV: _ positions for AAP (or equivalent) modules
   4. Conduit Connections: _ positions for 1.25-inch conduits at top, _ positions for 1.25-inch conduits at bottom, _ positions for 1.25-inch conduits at each side,
E. Manufacturers:
   1. FSR
      a. #PWB-100; in-wall multi-service box for flat panel display
      b. #PWB-200; in-wall multi-service box for flat panel display
      c. #PWB-250; in-wall multi-service box for flat panel display
      d. Refer to 27 41 16 for AV accessories
      e. Refer to 27 15 13 for telecom accessories
   2. Wiremold
      a. #EFSB2; 2-gang in-wall multi-service box for flat panel display
      b. #EFSB4; 4-gang in-wall multi-service box for flat panel display
      c. Refer to 27 41 16 for AV accessories
      d. Refer to 27 15 13 for telecom accessories
   3. Or equal
F. Application: indoor use as a multi-service (telecommunications, audiovisual, power) outlet box to house wiring, cabling, termination, connectors, and receptacles and serve a flat panel display
G. Listings: Wall boxes shall be listed by a nationally recognized testing laboratory to UL 514A.
H. Fabrication Material: Backbox: Seam welded 14 gauge steel; Cover: 1/16” steel, electro-painted
I. Outlet box shall feature capacity for the following:
   1. Power: 1 duplex receptacle, duplex or decora style
   2. Telecom/Network: 2 network jacks (refer to section 271513 for jack information)
   3. AV: _ positions for AAP (or equivalent) modules
   4. Conduit Connections: _ positions for 1.25-inch conduits at top, _ positions for 1.25-inch conduits at bottom, _ positions for 1.25-inch conduits at each side,
J. Manufacturers:
   1. Chief Manufacturing
      a. #PAC521P; in-wall multi-service box for flat panel display
      b. #PAC516; in-wall pre-wire box for flat panel display
      c. #PAC522; in-wall pre-wire box for flat panel display
      d. Refer to 27 41 16 for AV accessories
      e. Refer to 27 15 13 for telecom accessories
   2. Or equal

PART 3 - EXECUTION

3.1 GENERAL
A. Comply with the Execution requirements of Section 27 00 00.

3.2 EXAMINATION AND PREPARATION

A. Prior to installation, plan routes and locations of pathway systems and coordinate with other trades and building systems (ductwork, plumbing, electrical raceways, wall construction, ceilings, etc.). Pathway systems shall not unnecessarily cross other trade’s work, shall not prevent removal of ceiling tiles or panels, and shall not block access to mechanical or electrical equipment. Provide offsets as required to avoid obstruction of pathway systems with other trades/systems.

B. Prior to installation, examine areas to receive pathways systems to verify conditions are ready for work and to verify conformance with manufacturer and specification tolerances. Notify the Owner’s Representative in writing of conditions that would adversely affect the installation, or subsequent

3.3 INSTALLATION

A. Secure raceway/pathway systems to building structures using approved support methods and components (fasteners, anchors, clamps, hangers, etc) and complaint to the CEC.

B. Conduit Systems, including Pull Boxes
1. Run conduit in groups/banks in the most direct route possible, parallel to building lines, and at elevations that avoid unnecessary offsets. Do not route conduit through areas in which flammable material may be stored, or over or adjacent to boilers, incinerators, hot water lines, or steam lines. Completed conduit systems installation shall not encroach into the ceiling height headroom of walkways or doorways.

2. Trapeze Supported Conduit Runs
   a. Support conduit runs using "trapeze" hangers fabricated from construction channel and threaded steel rods anchored to building structures. Fasten conduit to construction channel using standard conduit clamps or equivalent.
   b. Seismically brace trapeze supports compliant to applicable codes.

3. Surface-Mounted Conduit Runs
   a. Single Conduit Runs: Support single conduit runs to building structure using construction channel with approved anchors and hardware or using 2-hole (preferred) or 1-hole conduit straps (or similar support apparatus). Where installed in damp or wet locations, support conduit to building structure using conduit clamp such that clamp backs add space between conduit and mounting substrate.
   b. Multiple Conduit Runs: Support multi-conduit runs to building structure using construction channel with approved anchors and hardware. Select anchors based on installation substrate. Fasten conduit to construction channel using standard conduit clamps or equivalent.
   c. Install vibration control apparatus as required to meet isolation requirements.

4. Install conduit free from dents, bruises or deformations. Remove and replace damaged conduits with new undamaged material.

5. Install metallic conduit so as to not be in contact with other dissimilar metal pipes (e.g., plumbing) to minimize galvanic corrosion.

6. Make bends and offsets using standard conduit bending hand tool and/or machines or use factory fittings. The use of any item not specifically designed for bending conduit is strictly prohibited.

7. When routing conduit within concrete:
a. Place conduits at a depth as required by the project’s structural engineer. In lieu of no direction, place conduits in the middle of the concrete’s depth.
b. Do not place conduits between reinforcing steel and the bottom of floor slabs.
c. Space conduits a minimum of three conduit diameters apart unless otherwise noted on the drawings.
d. Avoid crossing conduits (to minimize displacement of concrete). Obtain written approval/detail from structural engineer for crossing and for instances not adhering to general structural details.
e. Only use compression fittings. Fully wrap fittings with duct tape.

8. For conduits that turn up and protrude from finished concrete, extend conduits 25mm – 75mm (1” to 3”) above the surface of the floor, unless conditions require other extension lengths.

9. Pull Boxes: Install pull boxes and junction boxes at locations that are accessible. Install pull boxes and junction boxes at locations that are concealed, unless as noted on drawings; pull boxes and junction boxes may be exposed in electrical rooms, utility rooms, storage areas, or when installed in ‘open’ spaces (such as no ceilings). Adjust locations and installation as coordinated with construction conditions and as required for seismic bracing. Within ceiling space (e.g., above ceiling grid), do not install higher than 1m (~3’) above grid.

10. Ream conduit ends cut in the field (non-factory) to eliminate sharp edges, burrs, etc.

11. Clean completed conduits of foreign matter and/or moisture (e.g., pull a bristle mandrel through).

12. Secure pull strings/mule tapes at conduit ends or within boxes to prevent recoiling back into duct.

13. After installation of conduit system and during ongoing general construction, protect conduits and tightly cover/seal open ends.

14. Leave no unused openings in any pull or junction box. Install close-up plugs as required to seal openings.

15. Label each conduit end in a clear manner by designating the location of the other conduit end (i.e. room name, junction box number, etc.). Indicate conduit length on the label.

16. For connections to equipment subject to movement, vibration, misalignment, cramped quarters, or noise transmission, use short length (maximum of 6ft) of the FMC or LFMC conduit. For installation in exterior locations, or humidity-laden atmosphere, corrosive atmosphere, water hose or spray wash down operations, and locations subject to seepage or dripping of oil, grease or water, use LFMC. Provide a green ground wire with FMC or LFMC conduit.

17. Terminations, Connections and Joints
   a. Securely connect conduits to boxes, cabinets, wireways, etc., using conduit connectors suitable for the application and one (or two) locknuts and, where required, an insulating bushing or insulated connectors. Torque threaded items to proper tightness.
   b. Where conduits are bonded to ground, securely attach grounding bushings and route bonding jumpers in as short of a path as possible to grounding point.
   c. Where joints and/or connections cannot be made tight, use a bonding jumper to maintain electrical continuity through the connection.
   d. Where terminations are subject to vibration, use a bonding bushing or wedge to maintain electrical continuity through the connection. Where subject to vibration or dampness, use insulating bushings to protect conductors.
   e. Vibration/Movement Isolation: At connections/terminations subject to vibration, movement, misalignment, and/or noise transmission, transition duct bank conduit to a short length (maximum of 2-3 feet) of LFMC. Secure conduit to structure immediately prior to the transition.

C. Outlet Boxes / Back Boxes
1. Install boxes plumb and square. Match heights of surrounding outlets (e.g., an adjacent electrical receptacle). Adjust locations and heights as required to suit coordination requirements of construction conditions.

2. Install boxes flush with walls, ceilings and floors except where exposed work is called for on the drawings, required, or appropriate.

3. Do not make unused openings in boxes (such as knocking out fabricated knock-outs without using the opening for a conduit connector). Replace boxes containing inadvertent or unused openings.

4. Framed Walls, both Fire Rated and Non-Rated
   a. Install outlet boxes and covers/raised rings during rough-in such that the finished condition is flush with wall finishes.
   b. Do not install outlet boxes back-to-back (outlet boxes facing opposite sides of a wall). At framed walls not fire rated, install boxes with at least 6” separation. At fire rated framed walls, install boxes with at least 24” and 1 framing stud separation.
   c. Patch/repair openings in wall (plaster, drywall, and/or plasterboard) around boxes and/or raised rings to eliminate visible gaps after outlet gets finished, in accordance with CEC 314.21.

5. Ceilings
   a. At ceilings, install boxes, supports (such as T-bar support bracket), and cover/ring such that the finished condition is flush with ceiling finishes, except where noted otherwise and where conditions prevent a flush installation
   b. At non-accessible ceilings, install service conduit continuous to an accessible location

6. Concrete Cast-In-Place Walls and Floors
   a. Set boxes in place within forms (for walls) and casting volume (for floors) such that the finished condition is flush with wall and floor finishes. Ensure proper concrete cover, according to structural requirements.

7. Masonry Walls
   a. Adjust position of outlet boxes to suit masonry course lines. Coordinate cutting of masonry walls to achieve neat openings for boxes.

D. Wall Boxes for Flat Panel Displays
   1. Install boxes plumb and square. Install boxes and covers/raised rings during rough-in such that the finished condition is flush with wall finishes. Patch openings around covers/raised rings to eliminate visible gaps after outlet gets finished.
   2. Confirm heights of each box. Coordinate with heights of associated services (e.g., electrical receptacle). Adjust locations and heights as required to coordinate with construction conditions.
   3. Do not make unused openings in boxes (such as knocking out fabricated knock-outs without using the opening for a conduit connector). Replace boxes containing inadvertent or unused openings.
   4. Do not install boxes back-to-back in a framed wall (boxes facing opposite sides of a wall), unless noted so on the drawings. At framed walls not fire rated, install boxes with at least 6” separation. At fire rated framed walls, install boxes with at least 24” and 1 framing stud separation.

E. Floor Boxes
   1. Install floor boxes square, plumb, level, and flush with structural floor. Align box with adjacent surfaces.
      a. Tolerance: 1/16"
2. For floor boxes with combined power and communications circuits, install metal dividers for separation of circuits.
3. Install covers to suit finish conditions. Coordinate floor finishes (such as carpet) with other trades.

F. Poke-Thrus
1. Install poke-thrus flush with structural floor.
2. Install covers to suit finish conditions. Coordinate floor finishes (such as carpet) with other trades.

3.4 PROTECTION
A. Protect installed products until completion of project.
B. Touch-up, repair or replace damaged products before Substantial Completion.

3.5 FINAL INSPECTION AND CERTIFICATION
A. Punch the Work of this Section compliant to the requirements of Section 27 00 00.
B. Comply with system acceptance and certification requirements of Section 27 00 00.

END OF SECTION
SECTION 27 05 36 COMMUNICATIONS BUILDING PATHWAYS – CABLE TRAYS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Cable tray systems as pathways within buildings to support low voltage systems
B. Related Sections
   1. Comply with the Related Sections paragraph of Section 27 00 00.
   2. Section 27 05 26, “Communications Grounding and Bonding”
   3. Section 27 11 00, “Communication Rooms”

1.2 REFERENCES

A. Comply with the References requirements of Section 27 00 00.
B. In addition to those codes, standards, etc., listed in 27 00 00, products (including fabrication process) and installation shall comply with the latest edition of the following applicable specifications and standards:
   1. ASTM International
      c. ASTM A 525, “General Requirements for Steel Sheet, Zinc-Coated Galvanized by the Hot-Dip Process”
      e. ASTM A 591, “Specifications for Electrodepositing Coatings of Zinc on steel wire or sheets”
      g. ASTM A 653, “Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot Dip Process”
      h. ASTM B 633, “Specification for Electrodeposited Coatings of Zinc on Iron and Steel”
      i. ASTM D 769, “Standard Specification for Black Oxide Coatings”
   2. International Electrotechnical Commission (IEC)
      a. IEC 61537, “Cable Tray Systems and Cable Ladder Systems for Cable Management”
   3. National Electrical Manufacturer Association (NEMA)
      a. NEMA VE 1 (also CAN/CSA C22.2 No. 126.1-09), “Metal Cable Tray Systems”
      b. NEMA VE 2, “Cable Tray Installation Guidelines”
   4. National Fire Protection Agency (NFPA)
      a. NFPA 70B, “Recommended Practice for Electrical Equipment Maintenance”
      b. NFPA 70E, “Standard For Electrical Safety In The Workplace”
   5. Underwriters Laboratories (UL)
a. UL 467, “Grounding and Bonding Equipment”

1.3 DEFINITIONS

A. Definitions of Section 27 00 00 apply to this Section.
B. In addition to those Definitions of Section 27 00 00, the following list of terms as used in this Section defined as follows:

1. “Cable Tray” and “Cable Tray System”: A unit or assembly of units or sections and associated fittings forming a structural system used to securely fasten or support cables and raceways.

2. “Wire Mesh Cable Tray”: A cable support and management system fabricated of continuous, rigid, welded steel wire mesh; available in many sizes with attachment hardware suitimg multiple installation methods; falls under NFPA 70’s definition as cable tray.

1.4 SYSTEM DESCRIPTION

A. Work Covered Under Other Sections:

1. Backbone Conduits/Duct Banks: Conduits, supports, pull boxes, and pull strings
2. Sleeves: Sleeves (pre-fabricated systems and/or EMT conduits) and supports

B. Wire Mesh Cable Tray Systems:

1. Provide a complete cable tray system in accordance with CEC Article 392 and Article 250 (for Grounding and Bonding), NEMA VE 1, NEMA VE 2, manufacturer’s instructions, and compliant to local inspections and seismic restraint requirements, UL listing requirements, NFPA 70E, NECA’s “Standards of Installation” pertaining to general electrical installation practices, and recognized industry practices. Cable tray system shall conform to ANSI/TIA-569-B standard and BICSI TDMM guidelines. Complete shall include straight sections, connectors/splices, bonding straps, supports, etc., necessary for a complete installation. Routes shown on the Drawings are diagrammatic in nature. Field verify route prior to installation.

2. Supports: Provide supports at each connection point (junction of 2 or more straight sections), direction transitions, at the end of each run, and at other locations necessary to attain a fully supported and seismically braced cable tray system using a structurally-approved anchoring system and in accordance with NEMA VE 2.

a. Allowable Support Methods:
   1) Trapeze (NEMA VE 2, Figure 4.1G)
   2) Single hanger clip (NEMA VE 2, Figure 4.2E)
   3) Wall cantilever (NEMA VE 2, Figures 4.7A and 4.7B)
   4) Wall vertical (NEMA VE 2, Figure 4.9D)

b. Disallowable Support Methods:
   1) Center hung (NEMA VE 2, Figure 4.3A)

3. Seismic Bracing: Provide seismic bracing to supports and tray system.

4. Splices: Provide UL classified splice systems by the same manufacturer as the straight sections.

a. Allowable Splice Methods: washer splice, splice plate, splice bar, wing splice (all splice methods shall be UL Classified)

5. Bend Radius: Cable tray system shall maintain a 12” (minimum) bend radius throughout.
6. Provide radius shields at each bend/corner of "T" type intersections and cross intersections.

7. Vertical Offsets: At vertical offsets 36 inch or less, provide a cable dropout on the higher-level tray section. At vertical offsets greater than 36 inches, provide a section of tray installed vertically between the upper and lower tray levels.

8. Bonding and Grounding
   a. Cable tray shall be electrically continuous maintaining minimum metal area requirements per NFPA 70 Table 392.7 (for use as an equipment grounding conductor). Where straight sections or field fittings have been modified during installation such that wires have been removed, provide bonding straps or other approved accessories to maintain minimum continuous area per electrical code.
   b. Provide external bonding strap at connections, expansion joints, sleeves, crossovers, and at other locations where system continuity is interrupted.
   c. Bond cable tray system to approved ground, as per CEC Article 250, using approved connection means.

9. Dropouts:
   a. Provide dropouts as shown on the drawings.
   b. In locations that require 18" wide or 24" wide dropouts, combine one 12" wide dropout with one 6" wide dropout to create an 18" wide dropout, or two 12" wide dropouts to create a 24" wide dropout.

10. Provide blind ends where tray termination is exposed (e.g., not at a wall).

C. Cable Tray Systems:

1. Provide a complete cable tray system in accordance with CEC Article 392 and Article 250 (for Grounding and Bonding), NEMA VE 1, NEMA VE 2, NEMA FG 1, manufacturer’s instructions, and compliant to local inspections and seismic restraint requirements, UL listing requirements, NFPA 70E, NECA’s “Standards of Installation” pertaining to general electrical installation practices, and recognized industry practices. Cable tray system shall conform to ANSI/TIA-569-B standard and BICSI TDMM guidelines. Complete shall include straight sections, fittings, connectors/splices, bonding straps, supports, etc., necessary for a complete installation. Routes shown on the Drawings are diagrammatic in nature. Field verify route prior to installation.

2. Supports: Provide supports at each connection point, direction transitions, at fittings, at the end of each run, and at other locations necessary to attain a fully supported and seismically braced cable tray system using a structurally-approved anchoring system and in accordance with NEMA VE 2.

   a. Allowable Support Methods:
      1) Trapeze (NEMA VE 2, 4.2.1.2)
      2) Hanger rod clamp (NEMA VE 2, 4.2.1.2)
      3) Wall cantilever (NEMA VE 2, 4.2.2)
      4) Wall vertical (NEMA VE 2, 4.2.4)

   b. Disallowable Support Methods:
      1) Center hung (NEMA VE 2, 4.2.1.3)

3. Seismic Bracing: Provide seismic bracing to supports and tray system.

4. Splices: Provide UL classified splice systems by the same manufacturer as the straight sections.

5. Expansion Connections: Provide expansion connectors where required per NEMA VE 1 and/or NEMA VE 2 and per manufacturer’s instructions.

6. Bend Radius: Cable tray system shall maintain a 12" (minimum) bend radius throughout.
7. Vertical Offsets: At vertical offsets 36 inch or less, provide a cable dropout on the higher level tray section. At vertical offsets greater than 36 inches, provide a section of tray installed vertically between the upper and lower tray levels.

8. Bonding and Grounding
   a. Cable tray shall be electrically continuous maintaining minimum metal area requirements per CEC Table 392.7 (for use as an equipment grounding conductor).
   b. Bond cable tray system to approved ground, as per CEC Article 250, using approved connection means.

9. Provide blind ends where tray termination is exposed (e.g., not at a wall).

D. Clearances (minimum):
   1. Installation heights and clearances between cable tray and building structures: Refer to Drawings
   2. Side and top access clearance: Refer to Drawings
   3. From fluorescent light fixtures, or other EMI sources: Refer to Drawings
   4. From any motor, transformer: Refer to Drawings
   5. From flue, hot water, steam line or other non-insulated heat sources: Refer to Drawings

E. Penetrations:
   1. Penetrate partitions and other construction assemblies, including fire rated assemblies, smoke barriers, smoke partitions, acoustic rated assemblies, etc., using approved methods.
   2. When penetrating concrete walls (including shear walls) and/or floors, scan the area to be penetrated and core openings using methods approved by the structural engineer and by the AHJ. Obtain written approval for locations and means when not using methods included in the contract documents.
   3. When penetrating fire rated assemblies, provide UL Classified and FM Approved fire rated systems in accordance with ASTM E814 (UL1479). Provide labels at both sides of the penetration. Refer to drawings for approved systems per application.
   4. When penetrating acoustic rated assemblies, provide solid bottom type cable tray with a solid cover extending 18 inches from the finished surface of the wall on both sides. Provide sealant to fill gaps, cavities, etc, to fully seal penetration.

1.5 SUBMITTALS

A. General: Conform to Submittal requirements as described in Section 27 00 00.
B. Quantity: Furnish quantities of each submittal as noted in Section 27 00 00.
C. Submittal Requirements Prior to the Start of Construction:
   1. Product Data: Submit product data showing manufacturers, part numbers, dimensions, fabrications materials, fabrication details, finishes, capacities, and accessories; also include certifications (factory-certified test reports of specified products, complying with IEC 61537, CEC, and NEMA VE 1)
      a. Submittal should include manufacturer's certification indicating ISO 9001 quality certified
   2. Shop Drawings: Submit shop drawings consisting of the following:
      a. Cable tray layout/routes, supports locations, support details
      b. Highlight proposed changes to pathways (routes, types, sizes, etc.) compared to the contract documents
      c. Clearance variations and/or requests for exceptions
d. Seismic bracing details (also see “Seismic Calculations” below)
e. Instances of penetrations through fire and smoke rated barriers, including calling out firestopping type/UL System, size, quantity, and other relevant information

D. Submittal Requirements at Close Out:
1. As-Built Drawings, showing the routes, dimensions, types, sizes, quantities, etc. (minimum)
2. O&M Manual, including as-builds, parts list, repair information, and maintenance requirements

E. Substitutions
1. Requests for substitutions shall conform to the general requirements and procedure outlined in Section 27 00 00.

1.6 QUALITY ASSURANCE
A. Comply with Quality Assurance requirements of section 27 00 00.
B. Manufacturer shall make available test reports witnessed by an independent testing laboratory of the “worst case” loading conditions and performed in accordance with the latest revision of NEMA VE 1
C. Materials and installation shall comply with CEC – construction and installation of cable tray and cable channel systems per Article 318, bonding per Article 250, and other articles as applicable per instance.
D. Installation shall comply with NFPA 70B, “Recommended Practice for Electrical Equipment Maintenance”.

1.7 DELIVERY, STORAGE, AND HANDLING
A. Comply with Delivery, Storage and Handling requirements of section 27 00 00.

1.8 WARRANTY
A. Comply with Warranty requirements of section 27 00 00.

PART 2 - PRODUCTS

2.1 CABLE TRAY – WIRE MESH TYPE
A. Application: Suitable for the support and management of communications cables overhead.
B. Tray shall be manufactured in accordance with NEMA VE1.
C. Material: Straight sections shall be fabricated from high strength steel wires and formed into a 2-inch by 2-inch (or 2-inch by 4-inch) wire mesh pattern with welded wire intersections. Wires shall meet the minimum mechanical properties of ASTM A510 Longitudinal wires shall be straight (with no bends). Wires diameter should be approximately 0.16” (4mm). Wire ends shall be rounded during manufacturing (for safety of cables and installers) or T-welded to the top wire along sides (flanges).
D. Finish: Electro-plate SC2 yellow zinc chromate, in accordance with ASTM B633.
E. Finishes:
1. **Electro-Plated Zinc Galvanizing:** Straight sections shall be made from steel meeting the minimum mechanical properties of ASTM A 510, Grade 1008 and shall be electro-plated zinc in accordance with ASTM B633, Type III, SC-1.

F. Splicing assemblies shall be the bolted-type using serrated flange locknuts. Hardware shall have yellow zinc chromate finish, in accordance with ASTM B633.

G. Size: Refer to Drawings for sizes.

H. Manufacturers:
   1. Chalfant Manufacturing wire mesh cable tray system
   2. Chatsworth Products “OnTrac” series wire mesh cable tray
   3. Cooper B-Line “Flextray” series wire mesh cable tray
   4. Legrand Cablofil wire mesh cable tray
   5. Mono-Systems “Mono-Mesh” wire mesh cable tray
   6. WBT
   7. Or equal

**PART 3 - EXECUTION**

3.1 **GENERAL**

A. Comply with the Execution requirements of Section 270000.

B. Install cable tray systems in accordance with manufacturers’ instructions, with NEMA VE2 and with recognized industry practices. Install cable tray systems compliant to requirements of CEC, applicable portions of NFPA 70B, and to NECA’s “Standards of Installation” pertaining to general electrical installation practices.

3.2 **PREPARATION**

A. Plan routes and locations of pathway systems and coordinate with other trades/systems (ductwork, plumbing, electrical raceways, wall construction, ceilings, etc.). Pathway systems shall not unnecessarily cross other trade’s work, shall not prevent removal of ceiling tiles or panels, and shall not block access to mechanical or electrical equipment. Provide offsets as required to avoid obstruction of pathway systems with other trades.

B. Prior to installation, examine areas to receive pathways systems to verify conditions are ready for work and to verify conformance with manufacturer and specification tolerances. Notify the Owner’s Representative in writing of conditions that would adversely affect the installation, or subsequent utilization, of the system. Proceed with installation when unsatisfactory conditions are corrected.

3.3 **INSTALLATION**

A. Do not anchor supports from ductwork, piping, or other equipment hangers.

B. Ensure no other trades/building systems conflict with cable tray systems and clearances. Other building infrastructure, such as columns, pipes, valves, etc., shall not route inside or through cable tray. Either relocate/alter other building infrastructure (preferred) or, if other building infrastructure cannot be altered, adjust the cable tray route to avoid conflicts other building infrastructure.

C. Install cable trays parallel or at right angles to the centerlines of columns and beams.

D. Round edges and smooth surfaces to eliminate sharp edges and spurs that could damage (cut, puncture, etc) cable jackets.
E. Thoroughly clean surfaces receiving connections for bonding.

F. Clearances: Ensure clearance and access requirements to cable tray – above, below, and side – as shown on the drawings are met. Coordinate with other trades to avoid other building infrastructure encroaching on access/clearance.

G. Fabricate fittings (tee, cross, reducers, and 90-degree turns) in the field according to the manufacturer’s instructions and to ensure the pathway system remains UL listed. Fabricate fittings by cutting wires with a cutting device approved by the manufacturer. Cut wires in a manner that minimizes sharp edges and projections to prevent damage to cables (such as cut outer jacket) or harm to installation personnel. Provide corner connectors that provide a radius on the inside corner of bends for horizontal 90 degree bends, tees, and crosses. Bends shall have a minimum of a 12-inch bend radius.

H. At transition to and/or interface with conduit, align end of cable tray directly underneath the conduits.

I. Bonding and Grounding
   1. Bond system per “System Description” requirements.

J. Protection: Protect installed system until completion of project. Touch-up, repair or replace damaged products before punch walk.

3.4 PRE-FUNCTIONAL TESTING

A. After installing cable tray systems, perform the following pre-functional testing.

B. Visually inspect the completed cable tray system for intrusion of items such as pipe, hangers, or other equipment. If found, notify Engineer (explain in detail the conflict and suggest means to eliminate the conflict). Adjust cable tray as approved to eliminate spatial conflict and to ensure clearance.

C. Visually inspect the completed cable tray system for mechanical continuity at each cable tray joint, fitting, junction, attachment to supports (e.g., hold-down clips), etc. Check the hardware for missing or damaged bolts, bolt heads, or nuts – if found, replace with specified hardware. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.

D. Visually inspect seismic bracing. Ensure each instance complies with approved methods and is complete (anchors, stiffeners, hardware, etc). Check the hardware for missing or damaged bolts, bolt heads, or nuts – if found, replace with specified hardware. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.

E. Visually inspect the completed cable tray system for vibration. If excessive vibration is found, provide vibration isolation apparatus as needed to eliminate vibration.

F. Visually inspect the completed cable tray system for thermal expansion and contraction conditions. If thermal expansion is identified, provide expansion fittings and other apparatus necessary to eliminate (or mitigate) expansion (and/or contraction).

G. Visually inspect the completed cable tray system for electrical continuity at each cable tray joint and each ground connection. Ensure adequacy of cable tray grounding. Verify that takeoff raceways are bonded to cable tray.

H. Visually inspect the completed cable tray system for sharp edges and corners. If found, grind or file edges and corners to smooth.

I. Visually inspect the completed cable tray system for deflections and protuberances; correct any not within specifications

J. Clean cable tray system: Remove deposits of dust, scrap materials, trash of any description, and any blockage of tray ventilation.

K. Record results of visual inspections. Submit pre-functional report to Engineer.

3.5 TESTING
A. Test cable tray systems in accordance with NFPA 70B Chapter 21 for electrical continuity and connection to approved ground. Measure ground resistance; verify cable tray is bonded to approved ground with a total resistance less than 5 ohms. Adjust bonding as needed to meet this requirement.

3.6 PROTECTION

A. Protect installed products until completion of project.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.

2. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

3. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials until the risk of damage is over.

B. Touch-up, repair or replace damaged products before Substantial Completion.

3.7 FINAL INSPECTION AND CERTIFICATION

A. Punch the work of this section compliant to the requirements of Section 27 00 00.

B. Comply with system acceptance and certification requirements of Section 27 00 00.

END OF SECTION
SECTION 27 08 11 COMMUNICATIONS TWISTED PAIR TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Testing of Communications Twisted Pair Cabling (both Backbone and Horizontal Cabling subsystems).
B. Related Sections
   1. Comply with the Related Sections paragraph of Section 27 00 00.
   2. Section 27 13 13 - Communication Backbone ISP Twisted Pair Cabling
   3. Section 27 13 14 - Communication Backbone OSP Twisted Pair Cabling
   4. Section 27 15 13 - Communication Horizontal Twisted Pair Cabling

1.2 REFERENCES

A. Comply with the References requirements of Section 27 00 00.
B. In addition to the References of Section 27 00 00, the following references apply to this specification:
   1. ANSI/TIA-1152, “Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling”

1.3 DEFINITIONS

A. Refer to Definitions of Section 270000, Section 27 13 13, Section 27 13 14, and Section 27 15 13.
B. In addition to those Definitions of Section 27 00 00, the following list of terms as used in this specification defined as follows:
   1. “CAT3”: Shall mean Category 3 cabling, per ANSI/TIA-568-C.2
   2. “CAT5E”: Shall mean Enhanced Category 5 cabling, per ANSI/TIA-568-C.2
   3. “CAT6”: Shall mean Category 6 cabling, per ANSI/TIA-568-C.2
   4. “CAT6A”: Shall mean Augmented Category 6 cabling, per ANSI/TIA-568-C.2
   5. “Channel”: Shall mean a testing configuration which includes the Permanent Link and the line cord (at the workstation), the equipment cord, and, if a full crossconnection is implemented, a patch cord and the crossconnect termination/connecting apparatus.
   6. “Connect”: Shall mean install all required patch cords, equipment cords, cross-connect wire, etc. to complete an electrical or optical circuit.
   7. “Cord”: Shall mean a length of cordage having connectors at each end. The term “Cord” is synonymous with the term “Jumper” and “Lead”.
   8. “Permanent Link”: Shall mean the ‘permanent’ portion of the Horizontal cabling to each outlet with the test cords de-embedded from the measurements; this includes cable, consolidation point (if used), termination/connecting apparatus in the IDF and the connector at the outlet.
   9. “System Cord”: Shall mean the cord used in the operating transmission circuit.
   10. “Test Cord”: Shall mean the cord certified for use in testing, as described in this section.

1.4 SYSTEM DESCRIPTION
A. Refer to Section 270000, Section 27 13 13, Section 27 13 14, and Section 27 15 13 for additional system description information.

B. Work Provided Under Other Sections

1. Backbone twisted pair cabling
2. Horizontal twisted pair cabling

C. Base Bid Work

1. Testing of a completed communication infrastructure cabling system, which includes:

   a. Submittals
   b. Testing of the twisted pair cabling as follows:

   **Table 270811-1.1: Tests For UTP Cabling**

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Type</th>
<th>Test</th>
<th>Configuration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backbone</td>
<td>OSP</td>
<td>*see “Notes”</td>
<td>-</td>
<td>Wire map &amp; length</td>
</tr>
<tr>
<td>Backbone</td>
<td>ISP/Riser</td>
<td>*see “Notes”</td>
<td>-</td>
<td>Wire map &amp; length</td>
</tr>
<tr>
<td>Horizontal</td>
<td>CAT6A</td>
<td>Category 6A</td>
<td>Permanent Link</td>
<td>Per TIA-568-C.2, 6.3</td>
</tr>
<tr>
<td>Horizontal</td>
<td>CAT6A</td>
<td>Category 6A</td>
<td>Channel</td>
<td>Per TIA-568-C.2, 6.2</td>
</tr>
</tbody>
</table>

   c. Record Documents, including test results.

1.5 SUBMITTALS

A. Comply with the Submittal requirements of Section 27 00 00.

B. Submittal Requirements at Start Of Construction:

2. Product Submittal, including cut sheets of testing equipment to be used (note all software/ firmware versions as applicable).
3. Schedule Submittal, consisting of proposed schedule of work. This schedule may be combined with the schedule developed for Division 27.

C. Submittal Requirements at Closeout:

1. Record Documents:

   a. Submit one hard copy and one soft copy of test reports, including all tested parameters. This may be combined with the reports of Section 27 08 21.
   b. Submit one hard copy of warranty certificate.

2. Format – Hard Copy:

   a. Prints of test reports, on 8.5”x 11” paper, color or black & white, one cabling link per page
   b. Assemble prints into a 3-ring binder
   c. Clearly label the cover of each test report binder with the following information:

      1) Client Name
      2) Project Name and Address
      3) Binder Name (e.g., “Test Reports for Horizontal Cabling System”)
      4) Date of Submittal – date format: month day, year (e.g., “January 1, 2020”)  
      5) Contractor Name

   d. Include a Table Of Contents at the beginning that lists the contents
   e. Organize the test reports by Backbone Cabling / Horizontal Cabling, by building, by floor, and by IDF.
   f. Sort reports in ascending cable ID order
g. Include tabbed separators for improved navigation through the manual

3. Format – Soft Copy:
   a. “Burn” onto one CD-ROM test report files as native data format (for example, an *.FLW file from a Fluke tester); if not possible to submit in native format, then issue test results as an exported Microsoft Excel compatible format.
   b. Include onto CD-ROM ‘Viewer’ software necessary to view, sort, filter, and print individual and summary test results from test results native format.
   c. Clearly label the CD-ROM with the following information:
      1) Client Name
      2) Project Name and Address
      3) CD-ROM Name (e.g., “Test Reports for Horizontal Cabling System”)
      4) Date of Submittal – date format: month day, year (e.g., “January 1, 2020”)
      5) Contractor Name

1.6 QUALITY ASSURANCE
   A. Comply with the Quality Assurance requirements of Section 27 00 00.
   B. Under no circumstances shall any cable’s and/or conductor’s test results be substituted for another’s. If an instance of falsification is confirmed, the Contractor is liable for a complete retest of the cabling system at no additional cost to the Owner. This includes the retaining the services of a neutral party to observe all retesting.

1.7 WARRANTY
   A. Warrant the validity of the test results.

PART 2 - PRODUCTS

2.1 BACKBONE TWISTED PAIR CABLING TESTER
   A. Areas of Test Measurement (minimum): Wire Map (continuity, opens, shorts, crossed pairs, split pairs): Siemon #MT-5000 test unit, with 25-pair adapter, or equal.

2.2 CATEGORY 6A HORIZONTAL CABLE TESTER
   A. Equipment shall be independently verified to meet ANSI/TIA-1152 requirements, including Level IIIe minimum accuracy. Equipment shall meet ISO/IEC Class C, D, E, and F.
   B. Test Standards (minimum): ANSI/TIA-568-C.2 Category 6A; ISO/IEC 11801 Class C and D; ISO/IEC 11801-2000 Class C and D, 1000Base-T, 100Base-TX; IEEE 802.3 10Base-T; ANSI TP-PMD; IEEE 802.5
   C. Areas of Test Measurement (minimum): test areas listed under ANSI/TIA568-C.2, 6.3
   D. Equipment:
      1. Fluke Networks
         a. #DTX-1800; “CableAnalyzer” test kit (main unit, remote unit, CAT6A permanent link adapters, CAT6A channel adapters, accessories), loaded with the latest firmware version.
         b. “LinkWare” reporting and latest version of documentation software
2.3 CATEGORY 3 HORIZONTAL CABLE TESTER

A. Test standards (minimum): TIA Category 3 per TIA TIA/EIA-568B; ISO/IEC 11801 Class C; ISO/IEC 11801-2000 Class C, 100Base-TX; IEEE 802.3 10Base-T; IEEE 802.5

B. Equipment shall be independently verified to meet ANSI/TIA-1152 requirements, including Level II minimum accuracy. Equipment shall meet ISO/IEC Class C.

C. Test Standards (minimum): ANSI/TIA-568-C.2 Category 3; ISO/IEC 11801 Class C; ISO/IEC 11801-2000 Class C, 100Base-TX; IEEE 802.3 10Base-T; ANSI TP-PMD; IEEE 802.5

D. Areas of Test Measurement (minimum): test areas listed under ANSI/TIA568-C.2, 6.3, as applicable to CAT3 cabling

E. Equipment

1. Fluke Networks
   a. #DTX-1800; "CableAnalyzer" test kit (main unit, remote unit, CAT6A permanent link adapters, CAT6A channel adapters, accessories), loaded with the latest firmware version.
   b. “LinkWare” reporting and latest version of documentation software
   c. DSP-4300 CableAnalyzer test unit, with “CableManager” reporting and documentation software (version 4.8, or higher)

2. Or equal

PART 3 - EXECUTION

3.1 SCHEDULING

A. Prepare a construction schedule based on the schedule developed in sections 27 15 13 and 27 15 23 for the testing activities. Update testing schedule when changes in the cabling schedules occur.

3.2 FIELD QUALITY CONTROL

A. Calibrate test sets and associated equipment per the manufacturers printed instructions at the beginning of each day’s testing and after each battery charge. Fully charge the test sets prior to each day’s testing to ensure proper operation.

B. Ensure test equipment and test cords are clean and undamaged during testing activities. Per the Engineer’s discretion, halt testing activity and clean testing equipment, test cords, and related apparatus.

3.3 BACKBONE TWISTED PAIR CABBING TESTING REQUIREMENTS AND PROCEDURES

A. Precautions

1. Adhere to the equipment manufacturer’s instructions during all testing.
2. Prior to any testing activity or any measurements taken, ensure the test equipment is at room temperature – approximately 70 degrees F (e.g., if necessary, bring the test equipment in from outdoors and let it set for about 15 minutes or for however long it takes to bring the test equipment to reach room temp).
3. Fully charge power sources before each day’s testing activity

B. Testing Requirements
1. Test backbone multipair cabling per “Base Bid Requirements” in Part 1 of this Section.
2. The installation will be accepted when testing has indicated availability of 100% terminated pairs.

C. Testing Procedures
1. Test continuity and wire map for all pairs.
2. Test length for 2% of pairs of each cable. Pairs shall be from different 25-pair binder groups.

D. Acceptable Test Result Measurements
1. Overall:
   a. Links which report a Fail, Fail* or Pass* for any of the individual tests shall result in an overall link Fail. All individual test results must result in a Pass to achieve an overall Pass.
   b. Any reconfiguration of a link components required as a result of a test Fail, must be re-tested for conformance.
   c. Remove and replace any cabling links failing to meet the criteria described in this specification, at no cost to the Owner, with cables that prove, in testing, to meet the minimum requirements.
2. Length
3. Wire Map: Provide continuous cable link and terminate all pairs correctly at both ends. No exceptions accepted.
4. Attenuation: The acceptable attenuation measurements for any CAT3 cabling link is that which is no greater than that listed in ANSI/EIA-568-C.2, 6.3 and as adjusted to length measurement.
5. Worst Pair-to-Pair Near End CrossTalk (NEXT) Loss: The acceptable worst pair-to-pair NEXT loss no greater than that listed in ANSI/EIA-568-C.2, 6.3 for CAT3 cabling.

E. Record Documents:
1. Permanently record test results.
2. Cable and pair identifiers of the test reports shall match the identifiers as labeled in the field – i.e., use the same ID on the cable label/termination label as what appears on the test reports.
3. Measurements shall carry a precision through no significant decimal place.
4. Each test report shall contain the following information (not necessarily in this order):
   a. Project name
   b. Cable identifier, pair number(s)
   c. Date measurement were obtained
   d. Operator (company and name)
   e. Test equipment model and serial number(s)
   f. Measurement results

3.4 HORIZONTAL CATEGORY 6A TESTING PROCEDURES

A. Precautions
1. Adhere to the equipment manufacturer's instructions during all testing.
2. Prior to any testing activity or any measurements taken, ensure the test equipment is at room temperature – approximately 70 degrees F (e.g., if necessary, bring the test equipment in from outdoors and let it set for about 15 minutes or for however long it takes to bring the test equipment to reach room temp).
3. Fully charge power sources before each day’s testing activity

B. Test Equipment Set Up

1. Set up the tester to perform a full CAT6A test, as a Permanent Link configuration.
2. If the tester has cable-specific test parameters pre-loaded, set up the tester as product-specific setting. If not, set as generic CAT6A.
3. Set the tester to save the full test results (all test points, graphs, etc.).
4. Save the test results with the associated cable link identifier.
5. Calibrate the test set per the manufacturer’s instructions.

C. Acceptable Test Result Measurements

1. Overall Test Results:
   a. The Owner shall accept only individual test results that result in a Pass.
   b. Links which report a Fail, Fail* or Pass* for any of the individual tests shall result in an overall link Fail.
   c. Any reconfiguration of link components required as a result of a test Fail, must be re-tested for conformance.
   d. Remove and replace any cabling links failing to meet the criteria described in this specification, at no cost to the Owner, with cables that prove, in testing, to meet the minimum requirements.

2. Wire Map: Correctly terminate all pairs of the cabling link at both ends. Provide only continuous pairs. No exceptions.

3. Length: Ninety-four meters is the maximum acceptable electrical length measurements for any cabling link measured under a Permanent Link configuration, including test cords.

4. Insertion Loss: The acceptable insertion loss measurements for any CAT6A cabling link is that which is no greater than that listed in ANSI/EIA-568-C.2, 6.3.

5. Worst Pair-to-Pair Near End CrossTalk (NEXT) Loss: The acceptable worst pair-to-pair NEXT loss for any CAT6A cable is that which is no greater than that listed in ANSI/EIA-568-C.2, 6.3.

6. Power Sum NEXT Loss: The acceptable power sum PS-NEXT loss for any CAT6A cable is that which is no greater than that listed in ANSI/EIA-568-C.2, 6.3.

7. Worst Pair-to-Pair ELFEXT and FEXT Loss: The acceptable worst pair-to-pair ELFEXT and loss for any CAT6A cable is that which is no greater than that listed in ANSI/EIA-568-C.2, 6.3.

8. Power Sum ELFEXT and FEXT Loss: The acceptable PS-ELFEXT and loss for any CAT6A cable is that which is no greater than that listed in ANSI/EIA-568-C.2, 6.3.

9. Alien Near End CrossTalk (ANEXT) Loss: The acceptable ANEXT loss for any CAT6A cable is that which is no greater than that listed in ANSI/EIA-568-C.2, 6.3.

10. Alien Far End CrossTalk (AFEXT) Loss: The acceptable AFEXT loss for any CAT6A cable is that which is no greater than that listed in ANSI/EIA-568-C.2, 6.3.

11. Return Loss: The acceptable return loss measurements for any CAT6A cable is that which is no greater than that listed in ANSI/EIA-568-C.2, 6.3.

12. Propagation Delay and Delay Skew: The acceptable propagation delay and delay skew measurements for any CAT6A cable is that which is no greater than that listed in ANSI/EIA-568-C.2, 6.3.

D. Record Documents:

1. Permanently record test results.
2. Export all of the numerical test results to a single spreadsheet in Microsoft Excel® 2003 (*.xls) or 2007 (*.xlsx) file format.
3. Submit test results at the conclusion of the testing to the Engineer for approval. Engineer will check these test reports for a format acceptable to the Owner, or Owner’s Representative.
4. For each Horizontal CAT6A test, record the following information:
   a. Project name and address
   b. Testing Company's and Operator's name
   c. Date of measurement
   d. Test equipment, including the following:
      1) Manufacturer, model, and serial number
      2) Date and time of last calibration
   e. Identification number of cable
   f. Overall test result

END OF SECTION
SECTION 27 08 21 COMMUNICATIONS FIBER OPTIC TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Testing of Telecommunications Backbone and Horizontal Fiber Optic Cabling.
B. Related Sections
   1. Comply with the Related Sections paragraph of Section 270000.
   2. Section 27 13 23 - Communication Backbone ISP Fiber Optic Cabling
   3. Section 27 13 24 - Communication Backbone OSP Fiber Optic Cabling
   4. Section 27 15 23 - Communication Horizontal Fiber Optic Cabling

1.2 REFERENCES

A. Comply with the References requirements of Section 27 00 00.
B. In addition, the following standards are referenced to this Section:
   1. TIA/EIA-526-14A (OFSTP-14), "Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant"
   2. TIA/EIA-526-7 (OFSTP-7), "Measurement of Optical Power Loss of Installed Singlemode Fiber Cable Plant"
   3. EIA/TIA-455-77 (FOTP-77), "Procedures To Qualify A Higher-Order Mode Filter For Measurements On Singlemode Fibers"
   4. EIA/TIA-455-78A (FOTP-78), "Spectral-Attenuation Cutback Measurement for Singlemode Optical Fibers"
   5. EIA-455-95 (FOTP-95), "Absolute Optical Power Test for Optical Fibers and Cables"
   8. BICSI Telecommunication Distribution Methods Manual (TDMM)

1.3 DEFINITIONS

A. Refer to Definitions of Section 270000, Section 27 13 23, and Section 27 13 24.
B. In addition to those Definitions of Section 270000, the following list of terms as used in this specification defined as follows:
   1. "Adapter" (associated with fiber connectivity): Shall mean a connecting device that joins 2 fiber connectors, either like or unlike
   2. "Connect": Shall mean install all required test cords, patch cords, system cords, etc. to complete an optical circuit
   3. "CPR": Coupled Power Ratio (according to TIA/EIA-526-14A Annex A
   4. "Cord": Shall mean a length of cordage having connectors at each end; the term "Cord" is synonymous with the term "Jumper"
   5. "Jumper": See "Cord"
   6. "OTDR": Shall mean Optical Time Domain Reflectometer
7. “Passive Link Segment”: Shall mean the cable, connectors, couplings, and splices between two fiber optic termination units
8. “System Cord”: Shall mean the cord used in the operating electrical or optical circuit.
9. “Test Cord”: Shall mean the cord certified for use in testing, as described in this section

1.4 SYSTEM DESCRIPTION

A. Refer to Section 27 00 00, Section 27 13 23, Section 27 13 24, and Section 27 15 23 for addition system description information.
B. Work Provided Under Other Sections
   1. Backbone fiber optic cabling
C. Base Bid Work
   1. Submittals: pre-testing and post-testing
   2. Testing of completed fiber optic passive link segment(s) per the following table:

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Type</th>
<th>Test</th>
<th>Direction</th>
<th>Wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backbone</td>
<td>Multimode</td>
<td>Optical Power Loss</td>
<td>Both</td>
<td>850nm and 1300nm</td>
</tr>
<tr>
<td>Backbone</td>
<td>Singlemode</td>
<td>Optical Power Loss</td>
<td>Both</td>
<td>1310nm and 1550nm</td>
</tr>
<tr>
<td>Backbone</td>
<td>Multimode</td>
<td>Characterization</td>
<td>Both</td>
<td>850nm and 1300nm</td>
</tr>
<tr>
<td>Backbone</td>
<td>Singlemode</td>
<td>Characterization</td>
<td>Both</td>
<td>1310nm and 1550nm</td>
</tr>
</tbody>
</table>

3. Record Documents, including test results

1.5 SUBMITTALS

A. Comply with the Submittal requirements of Section 27 00 00.
B. Submittal Requirements at Start Of Construction:
   2. Pre-Testing Loss Calculations Submittal: Calculate the loss of each segment. The cable length may be based on the footage markings printed on the cable jacket. Include a brief description of each segment.
   3. Product Submittal, including cut sheets of testing equipment and the following information (this data must match the test reports):
      a. Manufacturer and model number
      b. Serial number
      c. Date of last factory calibration
      d. Software/ firmware versions (as applicable)
   4. Schedule Submittal, consisting of proposed schedule of work (this schedule may be combined with the schedule developed for Division 27)
C. Submittal Requirements at Closeout:
   1. Submit test results and reports in a format acceptable to the Owner, or Owner’s Representative, or Engineer before system acceptance.
2. Submit one soft copy and one hard copy of test reports, including all tested parameters. This may be combined with the reports of Section 27 08 11.
3. Submit one hard copy of warranty certificate from the manufacturer and the Contractor
4. Each test report (per strand per cable link) shall include the following information:
   a. Project/Client name, and project address
   b. Date of test
   c. Contractor (Company) and Technician’s name
   d. Test equipment, including Serial Numbers (*must match pre-testing submittal*)
   e. Test procedure (e.g., OFSTP-14A) and method (e.g., Method B)
   f. Light source’s launch category (including CPR) and spectral width
   g. Wavelength
   h. Cable identifier, fiber number, and fiber type (e.g., “multimode”)
   i. Measurement direction, including end locations
   j. Optical loss measurement
5. Cable and fiber identifiers of the test reports shall match the identifiers as labeled in the field – i.e., the ID stored with the test result shall be the same ID as on the cable label/fiber port label.
6. Format – Soft Copy:
   a. “Burn” onto one CD-ROM test report files as native data format (for example, an *.FLW file from a Fluke tester). If not possible to submit in native format, then issue test results as an exported Microsoft Excel compatible format.
   b. Include onto CD-ROM (or separate CD-ROM) ‘Viewer’ software necessary to view, sort, filter, and print individual and summary test results from test results native format.
   c. Clearly label the CD-ROM with the following information:
      1) Owner Name
      2) Project Name and Address
      3) CD-ROM Name (e.g., “Test Reports for Backbone Cabling System”)  
      4) Date of Submittal – date format: <month> <day>, <year> (e.g., “January 1, 2010”)  
      5) Contractor Name
7. Format – Hard Copy of Optical Loss Testing:
   a. Prints of test reports, on 8.5”x11” paper, color or black & white, one cabling link per page
   b. Assemble prints into a 3-ring binder
   c. Clearly label the cover of each test reports binder with the following information:
      1) Owner Name
      2) Project Name and Address
      3) Binder Name (e.g., “Test Reports for Backbone Cabling System”)  
      4) Date of Submittal – date format: monthday, year (e.g., “January 1, 2020”)  
      5) Contractor Name
   d. Include a Table Of Contents at the beginning that lists the contents
   e. Organize the test reports by Backbone Cabling / Horizontal Cabling, by building, by floor, and by IDF.
   f. Sort reports in ascending cable ID order
   g. Include tabbed separators for improved navigation through the manual
8. Format – Hard Copy of Characterization:
   a. Use feet for the units for distance measurements (i.e., the “X” axis of the graph) shown on the print of the test measurements.
b. Print reports such that strands of a given cabling link have matching axis scales; the x-axis shall be the same report-to-report and as well as the y-axis shall match report-to-report.

c. The trace of the printed test report shall show the launch cord.

d. Each test report shall contain the following information (not necessarily in this order):
   1) Owner Name
   2) Project Name and Address
   3) Cable identifier, fiber/strand number, and fiber type (e.g., “multimode”)
   4) Operator (company and name)
   5) Date measurements were obtained
   6) Measurement direction
   7) Set up parameters (such as wavelength, pulse width, refractive index, event threshold)
   8) Test equipment model and serial number(s)
   9) OTDR trace
   10) Length of fiber
   11) Overall link loss
   12) Contractor Name

e. For each cabling link, include either a schematic graphic or a brief narrative accurately describing the test set up. The description shall include test/launch cord (with length), expected events (connectors, slices, etc.) with expected distances, etc. This information will eliminate many questions the Engineer will have while reviewing the reports.

1.6 QUALITY ASSURANCE

A. Comply with the Quality Assurance requirements of Section 27 00 00.
B. Testing equipment shall be fully functional and in proper working order. Testing equipment shall be factory calibrated within the manufacturer’s published calibration period. Testing equipment must have loaded the latest firmware / operating software.
C. Under no circumstances shall any cable’s and/or optical conductor’s test results be substituted for another’s. If an instance of falsification is confirmed, the Contractor will be liable for a complete retest of the cabling system at no additional cost to the Owner. This includes the retaining the services of a neutral party to observe all retesting.

1.7 WARRANTY

A. Warrant the validity of the test results. Issue such warranty in writing.

PART 2 - PRODUCTS

2.1 FIBER OPTIC LIGHT SOURCE

A. Light source used for testing multimode fibers shall confirm to TIA/EIA-526-14A, 3.1. Light source used for testing singlemode fibers shall confirm to TIA-526-7, 3.1.1.
B. Light source’s modal launch condition shall be Category 1.
C. Light source’s connection interfaces shall be factory installed. Field-configurable connection interface will not be allowed.
D. Light source’s output wavelength and power shall be constant/unchanged after setting.
E. Light source shall be factory calibrated (date of last factory calibration must be documented).

F. Equipment:
1. Corning Cable Systems
   a. #OS-403RD; dual wavelength (850 / 1300) light source for multimode
   b. #OS-404RXD; dual wavelength (1310 / 1550) light source for singlemode

2. Exfo
   a. #FOT-930; OLTS test set
   b. #FOT-600 OLTS test set (#23BL Source + #602X Meter)
   c. #FOT-300; OLTS test set

3. Fluke Networks
   a. #DTX-1800; “DTX CableAnalyze” Test Kit – or bundled kit
   b. #DTX-MFM2 Fiber Module, for Multimode Fiber
   c. #DTX-GFM2 Gigabit Fiber Module, for Multimode Fiber
   d. #DTX-SFM2 Fiber Module, for Singlemode Fiber
   e. “SimpliFiber” Test Kit

2.2 FIBER OPTIC POWER METER

A. Power meters used for testing multimode fibers shall conform to TIA/EIA-526-14A, 3.2. Power meters used for testing singlemode fibers shall conform to TIA/EIA-526-7, 3.1.2.

B. Power meter shall be capable of measuring both relative and absolute power, and shall feature data storage (of measurements).

C. Power meter used shall have the following performance:
   1. Dynamic range of 0dBm to -50dBm, minimum
   2. Accuracy of ±0.2dB

D. Power meter shall be factory calibrated (date of last factory calibration must be documented).

E. Equipment:
1. Corning Cable Systems
   a. #OTS-610; power meter with data storage
   b. #OTS-400 series power meter (legacy product series)

2. Exfo
   a. #FOT-930; OLTS test set
   b. #FOT-600 OLTS test set (#23BL Source + #602X Meter)
   c. #FOT-300; OLTS test set

3. Fluke Networks
   a. #DTX-1800; “DTX CableAnalyze” Test Kit – or bundled kit
   b. #DTX-MFM2 Fiber Module, for Multimode Fiber
   c. #DTX-GFM2 Gigabit Fiber Module, for Multimode Fiber
   d. #DTX-SFM2 Fiber Module, for Singlemode Fiber
   e. “SimpliFiber” Test Kit

2.3 FIBER OPTIC MANDREL

A. For 50/125 μm fiber: 22 mm mandrel diameter for jacketed (3.0 mm) fiber.

B. Equipment:
1. Fluke Networks  
   a. #NF-MANDREL-50; red mandrel for jacketed 50/125 um fiber

2.4 FIBER OPTIC OTDR

A. Multimode Source Module:  
   - Wavelength  
     | Dynamic Range | Attenuation Deadzone | Reflective Deadzone | Loss Resolution | Distance Accuracy |
     | 850nm          | 24dB                 | 6.5mt               | 3.0mt          | 0.001dB         | 0.1mt           |
     | 1300nm         | 27dB                 | 7.0mt               | 3.0mt          | 0.001dB         | 0.1mt           |

B. Singlemode Source Module:  
   - Wavelength  
     | Dynamic Range | Attenuation Deadzone | Reflective Deadzone | Loss Resolution | Distance Accuracy |
     | 1310nm         | 40dB                 | 6.0mt               | 3.5mt          | 0.001dB         | 0.1mt           |
     | 1550nm         | 28dB                 | 12.0mt              | 3.5mt          | 0.001dB         | 0.1mt           |

C. Equipment:  
   1. Corning Cable Systems  
      a. #OV-1000; OTDR ‘mainframe’  
      b. #400-MD26; multimode module for OV-1000 OTDR  
      c. #400-SD34; singlemode module for OV-1000 OTDR  
      d. #2001HR; for multimode & singlemode systems (legacy product series)  
      e. #340 OTDR Plus Multitester II (legacy product series)  
      f. #MiniOTDR+; for multimode & singlemode systems (legacy product series)  
   2. Exfo  
      a. #FTB-500 platform OTDR  
      b. #FTB-200 platform compact OTDR  
   3. Fluke Networks  
      a. #OF-500; “OptiFiber” OTDR mainframe – or bundled kit  
      b. #OFTM-5610B; Multimode module for OptiFiber OTDR  
      c. #OFTM-5730; Singlemode module for OptiFiber OTDR  
      d. #OFTM-5610B; Multimode module for OptiFiber OTDR  

D. Reader Software: Windows-based software capable of reading stored traces and is fully functional with the testing equipment.

2.5 FIBER OPTIC TEST CORDS

A. Multimode Fiber Optic Test Cord  
   1. Multimode test cords shall conform to TIA-526-14A, 3.3.  
   2. The fiber of the multimode test cord(s) shall have the core diameter to that of the multimode fiber optic passive link under test.  
   3. Connectors of the test cords shall be compatible with (the same type as) the connector types of the light source and the power meter, and with the cabling plant.  
   4. The connectors shall exhibit ≤ 0.5dB loss per connection @ both 850nm and 1300nm, as measured per FOTP-171 D2.  
   5. Test cord length for Optical Power Loss testing: 1m - 5m.
B. Singlemode Fiber Optic Test Cord
   1. Singlemode test cords shall comply to 526-14A, 3.1.3.
   2. The fiber of the singlemode test cord(s) shall have the mode field diameter nominally equal to that of the singlemode fiber optic passive link.
   3. Connectors of the test cords shall be compatible (the same type) with the connector types of the light source and the power meter, and with the cabling plant.
   4. The connectors shall exhibit ≤ 0.5dB loss per connection @ both 1310nm and 1550nm, as measured per FOTP-171 D3. The connectors shall inhibit Fresnel reflections (i.e., have a “PC” finish).
   5. Test cord length for Optical Power Loss testing: 1m - 5m.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Prior to the start of testing, set up a meeting with the Engineer to witness testing procedures. The Engineer will, at their discretion, come to the site and witness the technician's actual testing procedures. The Engineer may give verbal comments to correct the technician's procedures to meet these requirements, followed up with a written observation report.

B. Calibrate test sets and associated equipment per the manufacturers printed instructions at the beginning of each day's testing and after each battery charge. Fully charge the test sets prior to each day's testing to ensure proper operation.

C. Use undamaged test equipment and test cords. Clean connectors and adapters (with a lint-free wipe and 90% (or higher) isopropyl alcohol) prior to and during testing activities. Per the Engineer's discretion, halt testing activity and clean testing equipment, test cords, and related apparatus.

D. Permanently record test results.

3.2 OPTICAL POWER LOSS TESTING REQUIREMENTS AND PROCEDURES

A. Safety: Use test equipment containing a laser or LED in accordance with ANSI Z136.2.

B. Test fiber optic passive links per "Base Bid Work" under System Description in Part 1 of this Section. Follow the procedures in the following order.

C. Precautions
   1. Adhere to the precautions described in TIA-526-14A, 5.1.
   2. Adhere to the equipment manufacturer's instructions during all testing.
   3. Prior to any testing activity or any measurements taken:
      a. Ensure test equipment is at room temperature – approximately 72 degrees F (if necessary, bring the test equipment in from outdoors and let it set until the test equipment reaches room temp).
      b. Power on the light source and power meter for at least 5 minutes prior to obtaining measurements.
      c. Clean connectors and adapters with a lint-free wipe and 90% (or higher) isopropyl alcohol.
   4. Do not power off the light source or the power meter during testing activity.
   5. Do not remove Test Cord #1 from the light source at any time (unless the testing is complete or the equipment is being put away for the evening).
   6. Do not bend the test cords smaller than 20 times the cord diameter (this may induce loss into the cord reducing the accuracy of the measurement).
D. Test Cord Performance Verification

1. Connect Test Cord #1 to the light source and to the power meter.
2. Set this value into the power meter as the reference power ($P_{ref}$).
3. Disconnect Test Cord #1 from the power meter. Do not disconnect Test Cord #1 from the light source.
4. Connect the ‘open’ end of Test Cord #1 to an adapter (of matching connector type). Connect one end of Test Cord #2 to that adapter and the other end of Test Cord #2 to the power meter.
5. The value displayed on the power meter represents the test cord #2 connection loss.
6. Flip the ends of Test Cord #2 so that the end connected to the power meter is now connected to the adapter (attached to test cord #1), and the end connected to the adapter is now connected to the power meter.
7. The value displayed on the power meter represents the test cord #2 connection loss on the opposite end.
8. Both connection loss measurements must be less than or equal to the value found in Table 270812-3.1 (below). Replace cord if measure losses exceed table values.

Table 270821-3.1: Acceptable Test Cord Connection Attenuation

<table>
<thead>
<tr>
<th></th>
<th>ST or SC Connection</th>
<th>LC and other Mini-Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multimode (50)</td>
<td>0.50 dB Max</td>
<td>0.20 dB Max</td>
</tr>
<tr>
<td>Singlemode</td>
<td>0.55 dB Max</td>
<td>0.30 dB Max</td>
</tr>
</tbody>
</table>

9. Repeat this test procedure from the beginning reversing the test cords in order to verify the performance of test cord #1.

E. Test Equipment Set Up

1. Follow the test equipment manufacturer’s initial adjustment and set up instructions.
2. Set the power meter to Relative Power Measurement Mode.
3. Set the meter to display power levels in dBm.
4. Set the light source and power meter to the same wavelength.

F. Multimode Passive Link Insertion Loss Testing Procedures

1. Only use a light source that exhibits a Category 1 modal launch condition. Confirm the light source’s modal launch condition following the procedures described in TIA-526-14A, Annex A.
2. Test Method:
   a. For ‘permanent’ links, perform the optical power loss testing of multimode fibers according to TIA-526-14A test method B “One Jumper Reference”.
   b. For ‘channel’ links, perform optical power loss testing of multimode fibers according to TIA-526-14A test method C “Three Jumper Reference” and include the system cords as part of the cable plant.

G. Singlemode Passive Link Insertion Loss Testing Procedures

1. Only use test jumpers that comply with the requirements TIA-526-7, 3.1.3.
2. Test Method:
   a. For ‘permanent’ links, perform the optical power loss testing of singlemode fibers according to TIA-526-7 test method A.1 “One Jumper-Cable Measurement”.
   b. For ‘channel’ links, perform optical power loss testing of singlemode fibers according to TIA-526-7 test method A.3 “Three Jumper-Cable Measurement” and include the system cords as part of the cable plant.
H. Acceptable Measurement Values
   1. The measured loss shall not exceed the calculated loss of the pre-testing submittals.

I. Record Test Measurements:
   1. Permanently record all test data per strand, including the following (minimum):
      a. Project name
      b. Cable identifier, fiber number, and fiber type (e.g., “multimode”)
      c. Testing company name
      d. Testing technician’s name
      e. Date measurements were obtained
      f. Measurement direction
      g. Wavelength
      h. Loss measurement
      i. Test equipment model and serial number(s)
   2. If the test set (light source and power meter) does not have data storage capability, then utilize the forms provided in Part 4 of this Section (or similar) as test reports.
   3. Measurements shall carry a precision through one significant decimal place, minimum.

3.3 CHARACTERIZATION TESTING REQUIREMENTS AND PROCEDURES

A. Safety: Use test equipment containing a laser or LED in accordance with ANSI Z136.2.

B. Test fiber optic passive links per “Base Bid Work” in Part 1 of this Section.

C. Precautions
   1. Adhere to the equipment manufacturer’s instructions during testing.
   2. Prior to testing activity or measurements taken, complete the following activities:
      a. Ensure the test equipment is at room temperature – approximately 70 degrees F (e.g., if necessary, bring the test equipment in from outdoors and let it set for about 15 minutes or for however long it takes to bring the test equipment to reach room temp).
      b. Turn the light source and power meter power on for at least 5 minutes.
      c. Clean test/launch cords’ and system cords’ connectors and the cabling system adapters with a lint-free wipe and 90% (or higher) isopropyl alcohol.
   3. Do not power off OTDR’s light source during testing activity.
   4. Do not remove launch cord from the OTDR’s light source at any time (unless the testing is complete or the equipment is being put away for the evening, or during trouble shooting).
   5. Do not bend the launch cord smaller than 20 times the cord diameter during testing activities (this may induce loss into the cord reducing the accuracy of the measurement).

D. Characterization Testing Procedures
   1. Equipment settings / measurement parameters:
      a. Index of Refraction: match cable-under-test fiber parameters; default settings as follows:
         Multimode Corning 50/125 Infinicor 1.481 @ 850nm 1.476 @ 1300nm
         Singlemode Corning SMF-28e+ 1.4670 @ 1310nm 1.4677 @ 1550nm
b. Pulse Width:
   Multimode 50/125  4 ns for cable lengths up to 300 meters
   20 ns for cable lengths between 300 meters and 2,000 meters
   Singlemode 10 ns for cable lengths up to 2,000 meters
   50 ns for cable lengths between 2,000 meters and 10,000 meters

c. Backscatter: multimode: -67dB @ 850nm, -74dB @ 1300nm; singlemode: -74dB @ 1310nm and 1550nm
d. Event Threshold: 0.05dB.
e. Reflection Threshold: multimode: -45dB, singlemode: -60dB.
f. Fiber Break/End-Of-Fiber: 3dB

2. Set the distance units (i.e., the "X" axis of the graph) to feet.
3. Waveform: The waveform shall be real-time and normal density.
4. Obtain measurements using a 'launch' cord connected to the test instrument and the cable-under-test.
   a. The fiber of the launch cord shall match the fiber of the cable-under-test in physical and performance parameters (such as type, core/cladding size, index of refraction, refractive profile). The fiber of the launch cord should match the fiber of the cable-under-test in manufacturer and product.
   b. The launch cord length shall be between 25 and 100 meters.

E. Record Test Measurements:
   1. Permanently record all test data per strand, including the following (minimum):
      a. Project name
      b. Contractor name
      c. Testing technician’s name
      d. Date measurements were obtained
      e. Cable identifier, strand number, and fiber type (e.g., “multimode”)
      f. Wavelength
      g. Measurement direction
      h. Full data set
      i. Curve
      j. Test equipment model and serial number(s)
   2. Measurements shall carry a precision through one significant decimal place, minimum.

PART 4 - TESTING FORMS

4.1 SUMMARY OF FORMS

A. Fiber Optic Test Instrument Data Sheet
B. Fiber Optic Reference Power Measurement Method Form
C. Fiber Optic Relative Power Measurement Method Form

END OF SECTION
## Fiber Optic Test Instrument Data Sheet

<table>
<thead>
<tr>
<th>LIGHT SOURCE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manufacturer:</strong></td>
<td><strong>Serial Number:</strong></td>
</tr>
<tr>
<td><strong>Model:</strong></td>
<td><strong>Last Calibration:</strong></td>
</tr>
<tr>
<td>Spectral Width:</td>
<td>Coupled Power Ratio (Category):</td>
</tr>
<tr>
<td>850-nm:</td>
<td>850-nm:</td>
</tr>
<tr>
<td>1300-nm:</td>
<td>1300-nm:</td>
</tr>
<tr>
<td>1310-nm:</td>
<td>1310-nm:</td>
</tr>
<tr>
<td>1550-nm:</td>
<td>1550-nm:</td>
</tr>
</tbody>
</table>

**Note:** Submit a separate data sheet for each test set being used.

<table>
<thead>
<tr>
<th>POWER METER</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manufacturer:</strong></td>
<td><strong>Serial Number:</strong></td>
</tr>
<tr>
<td><strong>Model:</strong></td>
<td><strong>Last Calibration:</strong></td>
</tr>
</tbody>
</table>
# Fiber Optic Reference Power Measurement Method Form

## TEST SUMMARY INFORMATION

<table>
<thead>
<tr>
<th>Test Personnel:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Source Location:</td>
<td>Power Meter Location:</td>
</tr>
<tr>
<td>Wavelength:</td>
<td>Reference Power Measurement ($P_{ref}$):</td>
</tr>
<tr>
<td>Method:</td>
<td></td>
</tr>
<tr>
<td>Page of</td>
<td></td>
</tr>
</tbody>
</table>

## TEST RESULTS

<table>
<thead>
<tr>
<th>Strand #</th>
<th>Cable ID</th>
<th>Power ($P_{sum}$) ($dB$)</th>
<th>Link Seg Attn ($dB$)</th>
<th>Accept Attn ($dB$)</th>
<th>Strand #</th>
<th>Cable ID</th>
<th>Power ($P_{sum}$) ($dB$)</th>
<th>Link Seg Attn ($dB$)</th>
<th>Accept Attn ($dB$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>33</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>34</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>36</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>38</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>39</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>43</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>44</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>46</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fiber Optic Relative Power Measurement Method Form

### TEST SUMMARY INFORMATION

<table>
<thead>
<tr>
<th>Test Personnel:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Source Location:</td>
<td>Power Meter Location:</td>
</tr>
<tr>
<td>Wavelength:</td>
<td>Method:</td>
</tr>
</tbody>
</table>

| Page _____ of _____ |

### TEST RESULTS

<table>
<thead>
<tr>
<th>Strand #</th>
<th>Cable ID</th>
<th>Link Seg Attn (dB)</th>
<th>Accep Attn (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strand #</th>
<th>Cable ID</th>
<th>Link Seg Attn (dB)</th>
<th>Accep Attn (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>47</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SECTION 27 11 00 COMMUNICATIONS EQUIPMENT ROOMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Buildout / fit-up of communications equipment rooms.
B. Related Divisions and Sections
   1. Comply with the Related Sections paragraph of Section 27 00 00.
   2. Review Seismic Calculation requirements, specifically in Section 27 00 00, Article 1.05.
   3. Drawings, general provisions of the Agreement, and Division 01 apply to this Section.
   4. Consult other Divisions, determine the extent and character of related work, and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable system.

1.2 REFERENCES

A. Comply with the References requirements of Section 27 00 00.
B. In addition to those codes, standards, etc., list in Section 27 00 00, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. EIA/ECA-310-E, “Cabinets, Racks, Panels, and Associated Equipment”
   2. NFPA National Fire Protection Association (NFPA) 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials

1.3 DEFINITIONS

A. Definitions as described in Section 27 00 00 shall apply to this section.
B. In addition to those Definitions of Section 27 00 00, the following list of terms as used in this specification defined as follows:
   1. “UPS”: Uninterruptible Power Supply – a system that provides conditioned power with batteries acting as a continuous power source for equipment during a utility power interruption

1.4 SYSTEM DESCRIPTION

A. General: Communications rooms shall fall into one of the following space titles:
   1. Building Distribution Facility
   2. Intermediate Distribution Facility

B. Room Functions:
   1. Building Distribution Facility (BDF) will serve the following functions:
a. House interbuilding twisted pair from the AA building and fiber optic from the Library backbone cabling, and house intrabuilding twisted pair and fiber optic backbone cabling to IDFs within the same building
b. House voice backbone crossconnect field and data backbone crossconnect field
c. House network equipment (i.e. distribution switches) serving the same building
d. Houses horizontal termination field, both voice and data, of devices served from this room (refer to floor plans for area served)
e. House network equipment (i.e. access switch) serving users of the room’s service area

2. Intermediate Distribution Facilities (IDF) will serve the following functions:
   a. House intrabuilding twisted pair and fiber optic backbone cabling from BDF
   b. House horizontal termination field – both voice and data – of outlets served from this room (refer to floor plans for area served)
   c. House network equipment (i.e. access switch) serving users of the room’s service area

C. Work Covered Under Other Sections
   1. Plywood backboards
   2. Bonding
   3. Grounding busbars
   4. Power and cooling
   5. Conduit, device boxes, and sleeves

D. Base Bid Work
   1. The Work under this section includes materials, accessories, fasteners, etc., and the labor and associated services required for the buildout / fit-up of telecommunications equipment rooms, and includes coordination through the General Contractor with other trades
   2. In general, the Work includes the following:
      a. Submittals
      b. Plywood backboards
      c. Rack bays (equipment racks, vertical management sections, anchoring)
      d. Cable, wire and patch cord management
      e. Overhead and vertical cable support
      f. IT Cabinets
      g. UPSs
      h. Seismic bracing
      i. Identification tags and labeling
      j. Record Documents
      k. Warranty

E. Coordination Requirements
   1. Electrical: Coordinate layout with electrical contractor to ensure proper placement of lighting, sequencing of power service to rack bay, and other issues related to electrical trade.
   2. Owner: Coordinate room-ready requirements and schedule with Owner (to allow Owner to plan and execute installation of OFOI telecommunications/network equipment). The contractor can’t bring up certain systems without the network so TRs need to be completed before those systems are brought up. TRs should be built-out with functioning lights, power, security, and climate control to be considered “ready”. 
1.5 SUBMITTALS
   A. Comply with the Submittal requirements of Section 27 00 00.
   B. Quantity: Furnish quantities of each submittal as noted in Section 27 00 00.
   C. Submittal Requirements at Start of Construction:
      1. Product Data Submittal
      2. Shop Drawings Submittal: Consisting of any proposed changes to room plans.
      3. Sample Submittal: Submit sample of equipment rack label.
      4. Schedule Submittal: Submit proposed schedule of work (this schedule may be combined with the schedule developed for Division 27).
   D. Submittal Requirements at Close Out:
      1. As-Built Drawings Submittal
   E. Substitutions
      1. Requests for substitutions shall conform to the general requirements and procedure outlined in Section 27 00 00.

1.6 QUALITY ASSURANCE
   A. Comply with Quality Assurance requirements of Section 27 00 00.

1.7 DELIVERY, STORAGE, AND HANDLING
   A. Comply with Delivery, Storage and Handling requirements of Section 27 00 00.

1.8 WARRANTY
   A. Warrant Work to perform as described within this Section for a period of 1 year. Correct deficiencies within 24 hours of notification.

PART 2 - PRODUCTS

2.1 SHEET HARDWOOD / PLYWOOD (AS BACKBOARD)
   A. A HP Grade A Type II (graded in accordance with AWI Premium)
   B. Materials shall comply with performance requirements in AWPA C27.
   C. The backboard must be 8’ x 4’ virgin plywood sheets, free from defects, and be fire rated.
   D. Fire-Retardant Treatment Processes: Plywood shall be chemically treated and pressure impregnated, capable of providing a maximum flame spread classification of 26-75 and a smoke density no greater than 450, in accordance with ASTM E 84.

2.2 FASTENERS, FOR PLYWOOD
   A. Bolts:
1. Bolts shall be steel and shall comply with ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6).
2. Hex nuts and flat washers shall comply with ASTM A 563 (ASTM F 563M).

B. Concrete Anchors:
1. Expansion anchor bolt and sleeve assemblies shall have a capability to sustain, without failure, a load equal to 6 times the load imposed when installed in concrete as determined by testing per ASTM E 488 conducted by a qualified independent testing inspecting agency.
2. Materials:
   a. Carbon-steel components, zinc plated to comply with ASTM B 633 Class Fe/Zn 5
   b. Galvanized machine screws or bolts with standard expansion-shield type concrete anchors
3. Manufacturers:
   a. Phillips Drill Co. “Red Head” masonry anchors
   b. Wej-It Expansion Products Inc. “Wej-It” concrete anchors
   c. Or equal

2.3 EQUIPMENT RACK – 4-CHANNEL TYPE

A. Application: Suitable for the support of termination apparatus, cable and cord management apparatus, network equipment, and other similar equipment, within a telecommunications room.
B. Material: High strength, lightweight 6061-T6 aluminum, extrusion construction.
C. Channel:
   1. Size: 3” deep, with flanges on each side (“double sided”)
   2. Flange: 1.265” wide by 0.25” thick, with mounting holes
   4. Threading: #12-24 rolled, compatible with EIA-310
   5. RMU Markings: The RMU markings shall be permanently stamped on the ‘outside’ of both flanges on both channels.

D. Assembled Rack: Rack shall be complete with four mounting channels, two base angles (3.5” high by 6” deep by .375” thick), two top angles (1.5” high by 1.5” deep by .375” thick), a bottom ‘center pan’, and a top ‘center pan’. Assembled rack shall be <7’-0” high (overall)> <8’-0” high (overall)> by 19” mounting width (20.25” wide overall), 28” from front mounting plane to back mounting plane, and shall contain <45> <51> EIA mounting spaces (1.75”). Racks must have adequate spacing in front and back to be serviceable. Contractors should confirm placement with campus rep before permanent installation.
E. Load Rating: 1,000 lbs, when evenly distributed for the height of the rack.
F. Finish: Black, powder coat
G. Manufacturer:
   1. CPI
      a. #50120-703; 7’-0”H x 19” x 29”D 4-channel rack, 45 RMU, black
   2. Cooper B-Line
      a. #SB8301908430FB; 7’-0”H x 19” x 30”D 4-channel rack, 45 RMU, black
   3. Or equal
2.4 EQUIPMENT RACK – 2-CHANNEL TYPE

A. Application: Suitable for the support of termination apparatus, cable and cord management apparatus, network equipment, and other similar equipment, within a telecommunications room.
B. Material: High strength, lightweight 6061-T6 aluminum, extrusion construction.
C. Channel:
   1. Size: 3” deep, with flanges on each side (“double sided”)
   2. Flange: 1.265” wide by 0.25” thick, with mounting holes
   4. Threading: #12-24 rolled, compatible with EIA-310
   5. RMU Markings: The RMU markings shall be permanently stamped on the ‘outside’ of both flanges on both channels.
D. Assembled Rack: Rack shall be complete with two mounting channels, two base angles (3.5” high by 6” deep by .375” thick), two top angles (1.5” high by 1.5” deep by .375” thick), and hardware. Assembled rack shall be 7’-0” high (overall by 19” mounting width (20.25” wide overall) and shall contain 45 EIA mounting spaces (1.75”). Racks must have adequate spacing in front and back to be serviceable. Contractors should confirm placement with campus rep before permanent installation.
E. Load Rating: 1,500 lbs when evenly distributed for the height of the rack.
F. Finish: Black, powder coat
G. Manufacturer:
   1. CPI
      a. #46353-703; 7’-0”H x 19” 2-channel equipment rack, 45 RMU, black
      b. #55053-703; 7’-0”H x 19” equipment rack, black
   2. Cooper B-Line
      a. #SB556084XUF; 7’-0”H x 19” equipment rack, black
   3. Or equal

2.5 SEISMIC GUSSET, FOR 2-CHANNEL EQUIPMENT RACK

A. Application: Seismic gusset kit for stiffening and stabilization of critical joints in equipment racks.
B. Manufacturer:
   1. CPI
      a. #11592-701; gusset kit, black
   2. Cooper B-Line
      a. #SB556 GUSSET KIT FB; gusset kit, black
   3. Or equal

2.6 VERTICAL MANAGEMENT SECTIONS

A. Application: Suitable for cable routing, cord routing, and cord slack storage vertically (between the top and bottom) within a rack bay.
B. The vertical management section shall be double-sided (i.e., the management section having covered cable guides on the front and flip-retainers on the rear).
C. Size & Capacity: Refer to the Drawings for sizes and configurations.
D. Mounting: The vertical management section having matching bolt holes for attachment to the rack.
E. Color: black (guides and cover).
F. Manufacturer:
   1. CPI
      a. #11729-703; vertical management section, 7’-0” x 6”, double sided, black
      b. #30162-703; 7’-0”H x 6"W, “CCS” double sided, black
      c. #40095-703; 7’-0”H x 6"W, “MCS-EFX” double sided, extended depth, black
   2. Cooper / B-Line
      a. #SB57166D084FB; 7’-0”H x 6"W, double sided, black
      b. #SB86086D084FB; 7’-0”H x 6"W, double sided, black
   3. Panduit
      a. #WMPVHC45E; vertical manager, 7’ x 6.7"W x 13.8”D, double sided, black
   4. Or equal

2.7 HORIZONTAL MANAGEMENT PANEL

A. Application: Suitable for installation into equipment rack for horizontal cord management. The horizontal management panel shall match (and fully integrate with) the vertical management sections.
B. The horizontal management panel shall be single-sided.
C. Size: 1U or 2U high (refer to Drawings) by 19” mounting wide.
D. Color: black (guides and cover).
E. Manufacturer:
   1. CPI
      a. #30139-719; horizontal management panel, single sided, 1U, black
      b. #30130-719; horizontal management panel, single sided, 2U, black
   2. Cooper / B-Line
      a. #SB87019S1FB; horizontal management panel, single sided, 1U, black
      b. #SB87019S2FB; horizontal management panel, single sided, 2U, black
   3. Panduit
      a. #NCMH2; horizontal cable manager with removable hinged front cover, double sided, 2U
      b. #NCMHF1; horizontal cable manager, single sided, 1U
   4. Or equal

2.8 CABLE RUNWAY

A. Cable Runway Straight Sections
   1. Application: Suitable for the support & management of telecommunications (and other low voltage) cables, either overhead or mounted vertically on a wall, within Telecommunications Room. Also overhead equipment rack bracing.
3. Material (both stringer and rung): Steel tube, rectangular, 1-1/2" by 3/8" by 0.65" wall thickness.
4. Size: 9' 11-1/2" straight sections; width: refer to Drawings.
5. Manufacturers:
   a. CPI
      1) #10250-718; 18"W cable runway, black
   b. Cooper / B-Line
      1) #SB17U18BFB; 18"W cable runway, black
   c. Or equal

B. Cable Runway Sweep Fittings
1. Application: Suitable for the support & management of telecommunications cables, overhead.
2. Material (both stringer and rung): Steel tube, rectangular, 1-1/2" by 3/8" by 0.65" wall thickness.
3. Manufacturer:
   a. CPI
      1) #10822-718; horizontal sweep fitting for 18" wide cable runway, black
      2) #10723-718; vertical outside sweep fitting for 18" wide cable runway, black
      3) #10724-718; vertical inside sweep fitting for 18" wide cable runway, black
   b. Cooper / B-Line
      1) #SB131890HB12FB; horizontal sweep fitting for 18" wide cable runway, black
      2) #SB131890VO12FB; vertical outside sweep fitting for 18" wide cable runway, black
      3) #SB131890VI12FB; vertical inside sweep fitting for 18" wide cable runway, black
   c. Or equal

C. Cable Runway Installation Accessories
1. Application: Installation accessories for use with cable runway.
2. Refer to Drawings for additional information and instances for installation.
3. Manufacturer:
   a. CPI
      1) #11301-001; butt splice kit
      2) #10487-001; swivel butt splice kit
      3) #11313-001; 45-degree junction kit
      4) #11314-001; 90-degree junction kit
      5) #11302-001; junction splice ("T") kit
      6) #10488-001; swivel junction splice ("T") kit
      7) #10608-001; vertical wall bracket kit
      8) #10642-001; end caps
      9) #11421-718; wall angle support kit for 18" wide cable runway, black
     10) #11312-718; triangle support kit for 12" and 18" wide cable runway, black
     11) #11770-718; end closing kit for 18" wide cable runway, black
     12) #10595-718; rack-to-runway attachment kit, for 18" wide runway, black
   b. Cooper / B-Line
      1) #SB6699¾x10½; grounding strap
      2) #SB2107BZ; butt splice kit, black
2.9 LABEL PLATES, FOR EQUIPMENT RACKS

A. Label plate shall be suitable to affix onto top angle of equipment rack or onto the top front of a frame/cabinet.
B. Label plate shall be ‘engrave-able’ stock melamine plastic laminate substrate.
C. Size (minimum): 1/2-inch high by 6 inches long by 1/16-inch thick.
D. Color: Black.
E. Lettering shall be white, engraved, 1/8-inch high.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the Execution requirements of Section 27 00 00.

3.2 EXAMINATION AND PREPARATION

A. Prior to installation, verify equipment rooms are suitable for the construction scope of this section. Schedule work to prevent damage caused by other trades during the course of that other construction.
B. Prepare surfaces, such as floors, for permanent installation of products, such as racks.

3.3 INSTALLATION

A. Plywood Backboards
   1. General
      a. Complete installation work in a neat, high quality manner and conform to all applicable federal, state and local codes, and all telephone standards.
      b. Replace or repair work completed by others that is defaced or destroyed by Work associated with installation of the plywood backboards. Contractor shall pay for the full cost of this repair/replacement.
c. Obtain written authorization from the General Contractor at least one week in advance of any drilling that may produce dust or particles in the air such as seismic anchorage into concrete sub-floor (so, for example, the Fire Protection System may be deactivated during such drilling).

2. Preparation
   a. Condition wood materials to average prevailing humidity conditions in installation areas prior to installing.
   b. Discard all units of material with defects that impair quality of carpentry and that are too small to use with minimum number of joints or optimum joint arrangement.

3. Plywood
   a. Install plywood in accordance with WIC Custom or Premium Quality Standard, as scheduled. Ensure work complies with applicable codes and recognized standards.
   b. Install plywood as indicated on Drawings to the dimensions shown. In lieu of no dimensions, install plywood from +0'-6" to +8'-6" above the finished floor.
   c. Install plywood plumb, level, true, and straight with no distortions. Shim as required using concealed shims.
   d. Trim plywood around electrical and telecommunications outlets.
   e. Install plywood such that the fire rating stamp is visible.
   f. Install plywood on all walls of TR not just ones designed to receive equipment.
   g. Install plywood to a tolerance of 1/8 inch in 8 feet for plumb and level; and with 1/16 inch maximum offset in flush adjoining, 1/8 inch maximum offsets in revealed adjoining surfaces.

4. Fasteners
   a. Install plywood using bolts, concrete anchors, or other fasteners suitable for the purpose.
   b. Provide nails, screws, anchors and other anchoring devices of the type, size, material, and finish required for application/mounting substrate.
   c. Do not use aluminum fasteners.
   d. Countersink fastener heads on exposed carpentry work and fill holes with wood filler.

5. Painting
   a. Paint plywood backboards with a low-gloss, white (or similar bright color) paint.
   b. Mask the plywood’s fire rated symbol/stamp from the paint such that the symbol/stamp is still visible after painting.

6. Cleaning, Finishing, and Protection
   a. Cleaning: Clean finish carpentry work on exposed and semi-exposed surfaces. Touch-up shop-applied finishes to restore damaged or soiled areas.
   b. Protection: Protect and maintain protection to ensure work will be without damage or deteriorating at time of acceptance.

B. Rack Bays

1. Equipment Racks
   a. Provide parts and accessories required to complete each rack. Completely assemble racks, according to manufacturer’s instructions.
   b. Anchoring/Bracing
      1) Use concrete anchors approved by structural engineer.
      2) Anchor racks to the structural floor at four points.
3) Brace racks overhead to overhead cable support where shown on the Drawings.

4) If required for seismic bracing, provide bracing devices (e.g., brackets, threaded rod with strut, etc.) attached to the wall or structure above using appropriate fasteners.

5) Racks must have adequate spacing in front and back to be serviceable. Contractors should confirm placement with campus rep before permanent installation.

2. Vertical Management Sections
   a. Provide vertical management sections as shown on Drawings. If not shown, provide a default of one vertical management section between each rack and at either end of the bay.
   b. Bolt vertical management sections to the equipment racks at the points designed by the manufacturer and per the manufacturer’s installation instructions.

3. Tolerances:
   a. Equipment Rack: Verify dimensions to establish proper clearances as follows:
      1) Front: 40” clearance from channel’s front mounting flange.
      2) Back: 57” clearance from channel’s back mounting flange.
   b. Provide the correct amount of space between each rack for proper installation (according to manufacturer’s written instructions) of the vertical management sections.

4. Horizontal Management Panels
   a. Provide horizontal management panels as shown on Drawings. If not shown, provide one management panel above each patch panel and one below the bottom patch panel in each rack bay where patch panels occur.
   b. Provide fasteners and parts required to complete the installation.

5. Accessories
   a. Provide rack mounting screws – 1 bag of screws per rack, as come packaged with the rack product. Attach the screws directly to the rack (visible for the punch walk). This shall constitute turn-over to the Owner.

C. Overhead Cable Support
   1. Provide support devices (e.g., brackets and threaded rod with strut) for overhead cable management system; install per the manufacturer’s instructions and fastened to the wall or ceiling using appropriate fasteners.
   2. Provide parts required for complete installation (e.g., mounting brackets, splice kits, hardware, etc.).
   3. Tolerances
      a. Install overhead cable support centered over the equipment rack, or as shown on the Drawings.
   4. Interface with Other Work: Coordinate the installation of the overhead cable support with other trades. Trapeze supports and ‘hanger rods’ (“all-thread”), for example, may be shared to lower overall construction cost.

D. Vertical Cable Support
   1. Provide cable runway installed vertically at the locations as shown on the Drawings for use to support cables routing vertically within telecommunications rooms.
2. Provide parts required for complete installation (e.g., vertical mounting brackets, bolts, etc.).
3. When using cable runway, install the runway such that the rungs are facing outward (the greater distance from the rung to the stringer edge is facing inward).

3.4 LABELING

A. General Requirements: Labeling and identifier assignment shall conform to ANSI/TIA-606-B and as approved by Owner before installation.
B. Equipment Rack Label Requirements: Provide one label plate per rack and IT cabinet. Permanently affix label plate and position as shown on the Drawings; if not shown on the Drawings, center the label plate on the rack’s front top angle or the cabinet’s top front frame.
C. Identifier Assignment
   1. Equipment Racks and IT Cabinets
      a. Prefix: “RACK” or “CABINET”
      b. First field: the room’s identifier; for example: “TR2.1”.
      c. Second field: the rack number (sequential numeral); for example: “01”.
      d. Example; “RACK TR2.1-01”

3.5 FINAL INSPECTION AND CERTIFICATION

A. Punch the Work of this Section compliant to the requirements of Section 27 00 00.
B. Comply with system acceptance and certification requirements of Section 27 00 00.

END OF SECTION
 SECTION 27 13 13 COMMUNICATIONS BACKBONE ISP TWISTED PAIR CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Backbone ISP (inside plant/indoor) twisted pair cabling.
B. Related Sections
   1. Comply with the Related Sections requirements of Section 27 00 00.
   2. Section 27 05 26, “Communications Grounding and Bonding”
   3. Section 27 08 11, “Communications Twisted Pair Testing”

1.2 REFERENCES

A. Comply with References requirements of Section 27 00 00.
B. In addition to the codes and standards listed in Section 27 00 00, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. National Fire Protection Agency (NFPA)
   2. Underwriters Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
      a. UL 444, “Communications Cables”
      b. UL 497, “Protectors for Paired-Conductor Communication Circuits”
      c. UL 497A, “Secondary Protectors for Communications Circuits”
      d. UL 497B, “Protectors for Data Communications and Fire-Alarm Circuits”
      e. UL 497C, “Protectors for Coaxial Communications Circuits”
      f. UL 1581, “Reference Standard for Electrical Wires, Cables, and Flexible Cords”
      g. UL 1666, “Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts”
      h. UL 1863, “Communications-Circuit Accessories”
   3. Insulated Cable Engineers Association (ICEA)
      a. ANSI/ICEA S-90-661-2008, “Category 3, 5, and 5e Individually Unshielded Twisted Pair Indoor Cable for Use In General Purpose and LAN Communication Wiring Systems”
   4. Telcordia
      a. GR-111, “Generic Requirements for Thermoplastic Insulated Riser Cable”

1.3 DEFINITIONS
A. Refer to Section 27 00 00 for Definitions.
B. In addition to those Definitions of Section 27 00 00, the following list of terms as used in this specification defined as follows:

1. “ALVYN”: sheath type consisting of corrugated polymer-coated aluminum shield with and adhered flame retardant jacket
2. “ARMM”: Bell system cable type (shielded riser)
3. “CMP”: Communications Media Plenum [NEC plenum rating]
4. “CMR”: Communications Media Riser [NEC riser/non-plenum rating]
5. “ISP”: Inside Plant [cabling]
6. “PE”: Polyethylene
7. “PIC”: Plastic Insulated Conductor
8. “PVC”: Polyvinyl Chloride
9. “PVDF”: Polyvinylidene fluoride

1.4 SYSTEM DESCRIPTION

A. Work Covered Under Other Sections

1. Pathways: The communications pathways (backbone conduits, riser sleeves, basketway, cable tray, etc.) work will be covered under another Section. Refer to the Drawings for size/capacity and route information.
2. Rooms: Build out (e.g., backboards, overhead and vertical cable runway, etc.) of the rooms (BDF, IDFs) will be covered under another Section. Refer to the Drawings for build out information.

B. Base Bid Work

1. Provide engineering, labor, materials, apparatus, tools, equipment, and transportation required to make a complete working telecommunications backbone twisted pair cabling system installation described in these specifications and shown on related Drawings.
2. The Drawings are diagrammatic in nature, and require shop drawings to complete the detailed design of the telecommunications infrastructure.
3. Consider backbone cabling shown on the Drawings as base bid work, unless otherwise noted. This includes terminations at both ends.
4. In general, the base bid work includes:
   a. Submittals
   b. Backbone inside plant (riser) twisted pair (copper) cables and termination apparatus
   c. Bonding (cable shield, termination apparatus, etc)
   d. Cable management
   e. Crossconnects
   f. Cable identification tags and system labeling
   g. Record Documents
   h. Warranty

1.5 SUBMITTALS

A. Comply with Submittal procedural, quantity, and format requirements of Section 27 00 00.
B. Submittal Requirements Prior To Start Of Construction:

1. Product Data Submittal, indicating conformance with NEC, UL, TIA/EIA listings, certifications and specifications.
2. Schedule Submittal, consisting of proposed schedule of work. This schedule may be combined with the schedule developed for Division 27.
3. Shop Drawings Submittal, consisting of proposed changes to cable routing, or termination locations/configurations.

C. Submittal Requirements at Closeout:
   1. As-Built Drawings
   2. Crossconnection records/cut sheets
   3. O & M Manuals

D. Substitutions
   1. Requests for substitutions shall conform to the general requirements and procedure outlined in Section 27 00 00.

1.6 QUALITY ASSURANCE
   A. Comply with Quality Assurance requirements of Section 27 00 00.
   B. Contractor Qualifications
      1. In addition to the Contractor Qualifications requirements of Section 27 00 00, the Contractor shall be manufacturer certified to install the proposed and submitted cabling system and to provide an extended warranty. Provide satisfactory evidence of certification in the form of a current letter or certificate from the manufacturer as part of the bid submission.

1.7 DELIVERY, STORAGE, AND HANDLING
   A. Comply with Delivery, Storage and Handling requirements of Section 27 00 00.

1.8 WARRANTY
   A. The telecommunications cabling system, as specified in this section, shall carry a 15-year (minimum) extended system warranty. This extended warranty shall cover parts and labor for the duration of the extended warranty. This extended warranty shall also cover electrical performance of cabling system to the specific category per ANSI/TIA/EIA-568-B performance criteria for backbone cabling.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. CommScope SYSTIMAX (substitutions allowed)

2.2 UNSHIELDED TWISTED PAIR CABLES – NON-PLENUM
   A. Application:
1. Cable suitable for indoor installation, between floors in vertical riser system, under access flooring, and through overhead ceiling space (in cable tray, conduit, & hangers).
2. Each and every cable run shall be a continuous single cable, homogenous in nature. Splices are not permitted anywhere.
3. Twisted pair PIC type, air core cable.

B. Conductors:
1. Annealed solid copper, 24 AWG
2. Fully insulated, consisting of a flame-retardant PVC or other thermoplastic.
3. Conductors twisted into pairs are stranded into 25-pair bundles and into units.

C. Core & Sheath:
1. Cable sheath shall consist of an overall flame-retardant PVC, or equivalent, jacket.
2. NEC rated as CMR and UL listed as such.

D. Performance:
1. Electrical performance of the twisted pairs and overall cable that complies with TIA/EIA-568-A requirements for Category 3 UTP cabling.

E. Manufacturers:
1. CommScope SYSTIMAX
   a. #1010 025AGY R1000 (106824329); 25 pair, 24 AWG, gray, CMR rated
2. BerkTek
   a. #10032396; 25 pair, 24 AWG, gray, CMR rated
3. General Cable
   a. #2133033; 25 pair, 24 AWG, gray, CMR rated

2.3 TERMINATION APPARATUS – “110 BLOCK” TYPE

A. Application:
1. Termination apparatus shall be “110 block” type.
2. Termination apparatus shall be suitable for installation within a telecommunication facility for the termination of the backbone twisted pair cables specified within this Section.
3. Termination apparatus shall be vertically oriented and suitable for wall-mount and/or rack-mount installations.
4. Termination should be in the TR racks in rj-45 patch panels. The 75 pair cable should connect to the AA building. Label pairs using campus pair count.
5. Termination apparatus, accompanied by the quantity of management panels, shall provide for both horizontal and vertical routing of cords and crossconnect wires, as shown on the drawings.

B. Manufacturer:
1. CommScope SYSTIMAX
   a. #110PA2-300FT; 110 Block kit, 300 pair, 5-pair based
   b. #188D3; vertical management panel for 300-pr block
2. **Panduit**
   a. P110KT3005Y; 110 Block kit, 300 pair, 5-pair based
   b. P110VCM300; vertical management panel for 300-Pr kit
   c. P110TB300Y; rack mounting bracket for 300-Pr kit
   d. P110TB900Y; rack mounting bracket for 300-Pr kit
   e. P110VCM; horizontal management panel

2.4 **TERMINATION APPARATUS – CAT5E PATCH PANEL, PUNCH DOWN TYPE**

A. **Application:** Patch panels shall be suitable for installation within a TR for the termination of the horizontal cables specified herein. Panels shall be horizontally oriented for a rack-mounted configuration. Panels shall be capable of supporting, organizing, labeling and patching/crossconnecting between the horizontal termination field and the equipment termination field.

B. **Patch panel shall have punch down type termination (general 110-type), and shall be compatible with the specified horizontal cables both electrically and physically.**

C. **Mechanical Performance:** Each port shall be an 8-position modular jack, compliant to ANSI/TIA-568.

D. **Electrical Performance:** Each port shall meet or exceed TIA-568 standard series and ISO/IEC 11801 requirements for CAT5E U/UTP cabling through the cable termination and patch cord connection.

E. **Manufacturer, or equal:**
   1. Belden “IBDN System 1200” “HD” Patch Panels. CAT5E
      a. AX103258; “HD” flat patch panel, 1U, 110 termination, 24 CAT5E ports
   2. CommScope SYSTIMAX “PowerSUM” Series
      a. 1100-U-PS-24; flat patch panel “PowerSUM”, 24 CAT5E ports
      b. 1100A-U-PS-24; angled patch panel “PowerSUM”, 24 CAT5E ports
   3. Leviton 110-Style Patch Panels
      a. 5G596-L24; flat patch panel, 1U, top lensed labeling, 24 CAT5E ports
      b. 5G596-U24; flat patch panel, 1U, top labeling, 24 CAT5E ports
   4. Panduit
      a. DP245E88TGY; “DP5e” flat patch panel, 24 CAT5E ports
      b. DPA245E88TGY; “DP5e” angled patch panel, 24 CAT5E ports

2.5 **CROSSCONNECT WIRE**

A. Crossconnect wire shall be suitable for installation within a telecommunication facility and fully compatible with the termination apparatus specified within this Section.
B. Crossconnect wire shall be manufactured from a single, continuous length of insulated wire, homogenous in nature. Splices are not permitted anywhere. Factory splices of insulated conductors are expressly prohibited.

C. Conductors:
   1. Conductors: 24 AWG solid copper
   2. Insulation: fully insulated conductors with a flame retardant thermoplastic (such as PVC, or equivalent)
   3. Twisted Pairs: Two insulated conductors “twisted” into a “pair” (twisted pair), individually color-coded.

D. Manufacturer:
   1. Belden B-Plus Crossconnect Wire
      a. #22208250; crossconnect wire, 1 pair, Wh/Bi
      b. #22208253; crossconnect wire, 1 pair, Wh/Bi, spool
      c. #22208260; crossconnect wire, 2 pair, Wh/Bi/Wh/Or
      d. #22208266; crossconnect wire, 3 pair, Wh/Bi/Wh/Or/Wh/Gr
      e. #22208270; crossconnect wire, 4 pair, Wh/Bi/Wh/Or/Wh/Gr/Wh/Br
   2. CommScope SYSTIMAX
      a. #CCW-F 1/24 S1000; crossconnect wire, 1 pair, Whi-Red / Red-Whi
      b. #CCW-F 1/24 S1000; crossconnect wire, 1 pair, Whi-Blu / Blu-Whi
   3. General
      a. #7023864; crossconnect wire, 1 pair, Red-Whi / Whi-Red
      b. #2114385; crossconnect wire, 1 pair, Red-Yel / Yel-Red
      c. #2114200; crossconnect wire, 1 pair, Red-Grn / Grn-Red
      d. #2114369; crossconnect wire, 1 pair, Red-Blu / Blu-Red
      e. #7023708; crossconnect wire, 1 pair, Red-Blk / Blk-Red
      f. #7041916; crossconnect wire, 1 pair, Blk-Yel / Yel-Blk
      g. #7023733; crossconnect wire, 1 pair, Org-Whi / Whi-Org
      h. #7023781; crossconnect wire, 1 pair, Grn-Whi / Whi-Grn
      i. #7036759; crossconnect wire, 1 pair, Blk-Whi / Whi-Blk
      j. #7023716; crossconnect wire, 2 pair, Blk-Whi/Whi-Blk // Org-Whi/Whi-Org
      k. #2114363; crossconnect wire, 1 pair, Whi-Org / Org-Whi
      l. #2114364; crossconnect wire, 1 pair, Whi-Grn / Grn-Whi
   4. Superior Essex
      a. #12-101-13; crossconnect wire, 1 pair, Red-Whi
      b. #12-102-13; crossconnect wire, 1 pair, Red-Yel
      c. #12-103-13; crossconnect wire, 1 pair, Whi-Blu
      d. #12-104-13; crossconnect wire, 1 pair, Vic-Blu
      e. #102-105-13; crossconnect wire, 1 pair, Blk-Whi
   5. Or equal

2.6 LABELS

A. Labels shall be machine printable with a laser printer, ink jet printer, thermal transfer printer, or hand-held printer.

B. Labels for Cables
   1. Labels shall be adhesive-backed and have a self-laminating feature
2. Labels shall fit the backbone cables listed above (i.e., shall fully wrap around the cable’s jacket).
3. Printable area should be 1 inch wide x 0.5 inch high, or larger
4. Printable area color shall be white
5. Manufacturer:
   a. Panduit
      1) #S200X400YAJ; labels for 25 to 100 pair cables [0.32” (8.09mm) - 0.95” (24.26mm) dia.]
      2) #S200X650YAJ; labels for 100 to 400 pair cables [0.48” (12.13mm) – 1.59” (40.43mm) dia.]
   b. Or equal

C. Termination Apparatus Labels
1. Labels shall be adhesive backed
2. Printable area color shall be white for backbone termination field and gray for ’2nd level’ backbone termination field
3. Manufacturer:
   a. CommScope SYSTIMAX
      1) #110WA2-4500L; 5-pair marked label inserts, white
   b. Panduit
      1) #DSL110; label inserts, white
   c. Or equal

PART 3 - EXECUTION

3.1 GENERAL
   A. Comply with the Execution requirements of Section 27 00 00.

3.2 EXAMINATION AND PREPARATION
   A. Rooms: Prior to installation, verify equipment rooms are suitable to accept the backbone twisted pair cables and terminations.
   B. Pathways: Prior to installation verify that pathways and supporting devices, provided under other sections, are properly installed, and that temporary supports, devices, etc., have been removed. Verify dimensions of pathways, including length (for example, “True Tape” the conduits).
   C. Cable Integrity: Prior to installation, verify the twisted pair cable is fully operational – both cable sheath and twisted pair conductors. Documentation of pre-installation testing is not a close out requirement, and is the responsibility of the Contractor.

3.3 INSTALLATION
   A. Backbone Cable Installation and Routing
      1. Cable runs shall have continuous sheath continuity, homogenous in nature. Splices are not permitted anywhere.
2. Maximum cable length of 500 meters from the termination within the MDF to the termination in Telecommunications Room.

3. Placement
   a. Place cables within designated pathways.
   b. Maintain a minimum bend radius of 6 times the cable diameter during and after installation.
   c. Maintain pulling tension within manufacturer’s limits.
   d. Place and suspend cables in a manner to protect them from physical interference or damage. Place cables with no kinks, twists, or impact damage to the sheath. Replace cables if damaged during installation.
   e. Place a pull rope along with cables where run in conduit and spare capacity still exists in the conduit. Tie off ends of the pull rope.

4. Routing
   a. When routing horizontally within telecommunications rooms, utilize the overhead cable support. When routing vertically within telecommunications rooms, utilize the vertical cable support and provide cable ties every 24 inches on center using.
   b. Route cables a minimum of 6” away from power sources to reduce interference from EMI.

5. Termination
   a. Provide 15 feet cable slack loop at each end of the run. Store slack in overhead cable support or as noted on Drawings.
   b. Properly relieve strain from cables at termination points per manufacturer’s instructions.
   c. Terminate twisted pairs onto the termination apparatus in accordance with manufacturer’s latest instructions and TIA/EIA-568-B standard installation practices.
   d. Bond cable shield – refer to section 27 05 26 for additional information. Provide shield bonding connector and either bonding braid or TBC to either termination apparatus ground block or directly to busbar.
   e. Perform post-installation testing as described in section 27 08 11.

B. Termination Apparatus
   1. Provide accessories required for a complete installation.
   2. Terminate cables and twisted pairs in accordance with manufacturer’s latest installation requirements and TIA-568 series standard installation practices. Terminate cable pairs onto the termination apparatus. Terminate twisted pairs compliant to TIA-568 series standards and wired per 1.04 System Description.
   3. Install the termination apparatus to the dimensions shown on the Drawings. If the dimensions are not shown, install the termination apparatus such that the bottom row of terminations is no lower than 24 inches (+/- 3”) AFF and the top row of terminations is no higher than 60 inches (+/- 3”) AFF.
   4. Mount termination apparatus plumb and square.
   5. Bond termination apparatus to grounding point (busbar) – refer to section 27 05 26 for additional information.

C. Patch Panels and Horizontal Management Panels
   1. Quantity: Provide patch panels to support termination of cables. Provide horizontal management panels based on the quantity of patch panels.
   2. Install and assemble discrete port patch panels and horizontal management panels according to the manufacturer’s instructions.
3. Install the patch panels and the horizontal management panels as shown on the contract drawings. If configuration is not shown, install the patch panels in association with the horizontal management panels such that a management panel is mounted above and below given patch panel.

D. Crossconnects
   1. In the BDF, provide one 1-pair crossconnect to length from the equipment field to the backbone field based on the records from the IDF crossconnections.
   2. Utilize the horizontal and vertical management components to properly route the crossconnect wire.
   3. Color:
      a. For digital handsets, provide: White-Blue / Blue-White
      b. For analog handsets, provide: White-Red / Red-White
   4. Splices in crossconnect wire are prohibited.

3.4 LABELING

A. General Requirements
   1. Labeling and identifier assignment and the label colors shall conform to the TIA/EIA-606-A Administration Standard and as approved by Owner or Owner’s Representative before installation.
   2. Provide permanent and machine-generated labels; hand written labels will not be accepted.

B. Cable Labels
   1. Label Format:
      a. Label type shall be wrap-around self-laminating.
      b. Label color shall be white background with clear laminating window.
      c. Text color shall be black; text height shall be 1/8" high, minimum, or #12 font size.
   2. Provide labels on both ends of cables. Fully wrap label around the cable jacket. Install labels no more than 4 inches from the edge of the cable jacket. Install labels such that they are visible by a technician from a normal stance.

C. Termination Apparatus Labels
   1. Use labels included in the product packaging. For substitutions, request approval by the Engineer.
   2. Label color shall be white for respective field type, per TIA/EIA-606-A.
   3. Text color shall be black, 3/32" high, minimum, or #10 font size.

D. Identifier Assignment
   1. General: Separate label fields of the identifier with a hyphen.
   2. Backbone ISP Twisted Pair Cables
      a. Refer to drawings.
   3. Termination Positions at the 110 Termination Blocks
      a. The first field shall identify the origination / destination room; for example “TO IDF2.2”.
      b. The second field shall identify the pair count range; for example, “0401-0450”
c. Identifier Example: “TO IDF2.2 0401 - 0450”.

3.5 FINAL INSPECTION AND CERTIFICATION

A. Punch the Work of this Section compliant to the requirements of Section 27 00 00.
B. Remove and replace with new, at no cost to the Owner, cables or conductors failing to meet the indicated standards and not passing the testing requirements of Section 27 08 11. The Owner, or Owner’s Representative, will not accept the installation until testing has indicated a 100% availability of all cables and conductors or the Owner or Owner’s Representative has approved any deviation from this requirement.
C. Comply with system acceptance and certification requirements of Section 27 00 00.

END OF SECTION
SECTION 27 13 14 COMMUNICATIONS BACKBONE OSP TWISTED PAIR CABLING

PART 1 - GENERAL

1.1 SUMMARY
A. Section Includes: Backbone OSP (outside plant) twisted pair cabling.
B. Related Sections
   1. Comply with the Related Sections requirements of Section 27 00 00.
   2. Section 27 08 11, “Communications Twisted Pair Testing”

1.2 REFERENCES
A. Comply with References requirements of Section 27 00 00.
B. In addition to the codes and standards listed in Section 27 00 00, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. Underwriters Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
      a. UL 497, “Protectors for Paired-Conductor Communication Circuits”
      b. UL 497A, “Secondary Protectors for Communications Circuits”
      c. UL 497B, “Protectors for Data Communications and Fire-Alarm Circuits”
      d. UL 497C, “Protectors for Coaxial Communications Circuits”
      e. UL 1863, “Communications-Circuit Accessories”
      f. UL 1863, “Communications-Circuit Accessories”
   2. Insulated Cable Engineers Association (ICEA)
   3. Telcordia
      a. GR-421-CORE Issue 2, “Generic Requirements for Metallic Telecommunications Cables”

1.3 DEFINITIONS
A. Refer to Section 27 00 00 for Definitions.
B. In addition, define the following list of terms as used in this specification as follows:
   1. “BEP”: Building Entrance Protection [systems]
   2. “CMP”: Communications Media Plenum [NEC plenum rating]
   3. “CMR”: Communications Media Riser [NEC riser/non-plenum rating]
   4. “HDPE”: High Density Polyethylene
   5. “ISP”: Inside Plant [cabling]
   6. “LDPE”: Light Density Polyethylene
   7. “OSP”: Outside Plant [cabling]
   8. “PE”: Polyethylene
9. “PIC”: Plastic Insulated Conductor
10. “PVC”: Polyvinyl Chloride

1.4 SYSTEM DESCRIPTION

A. Work Provided Under Other Sections
   1. Telecommunications Pathways
      a. Pathways (underground conduits, maintenance holes, pull boxes, pull ropes, etc.) will be provided under other Sections.
      b. Refer to the Drawings for size/capacity and route information.
   2. Telecommunications Rooms
      a. Buildout (e.g., backboards, overhead and vertical cable runway, etc.) of the telecommunications rooms (BDFs, IDF) work will be covered under another Section.
      b. Refer to the Drawings for buildout information.

B. Base Bid Work
   1. Provide engineering, labor, materials, apparatus, tools, equipment, and transportation required to make a complete working telecommunications backbone twisted pair cabling system installation described in these specifications and shown on related Drawings.
   2. The Drawings are diagrammatic in nature, and require shop drawings to complete the detailed design of the communications infrastructure.
   3. Consider Backbone cabling as shown on Drawings as base bid work, unless otherwise noted. This includes terminations at both ends.
   4. In general, the base bid work includes:
      a. Submittals
      b. Backbone outside plant (interbuilding) twisted pair (copper) cables and terminations
      c. Building entrance protection and terminal
      d. Splicing apparatus
      e. Cable management
      f. Crossconnects
      g. Cable identification tags and system labeling
      h. Record Documents
      i. Warranty

1.5 SUBMITTALS

A. Comply with Submittal procedural, quantity, and format requirements of Section 270000.
B. Submittal Requirements Prior To Start Of Construction:
   1. Product Data Submittal, indicating conformance with NEC, UL, TIA/EIA listings, certifications and specifications.
   2. Sample Submittal, consisting of the following components:
   3. Schedule Submittal, consisting of proposed schedule of Work. This schedule may be combined with the schedule developed for other Sections within Division 27.
   4. Shop Drawings Submittal, consisting of proposed changes to cable routing, or termination locations/configurations.

C. Submittal Requirements at Closeout:
1. As-Built Drawings.
2. Crossconnection records/cut sheets.
3. O & M Manuals.

1.6 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of Section 270000.
B. Contractor Qualifications
   1. In addition to the Contractor Qualifications requirements of Section 270000, the Contractor shall be manufacturer certified to install the proposed and submitted cabling system and to provide an extended warranty. Provide satisfactory evidence of certification in the form of a current letter or certificate from the manufacturer as part of the bid submission.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with Delivery, Storage and Handling requirements of Section 27 00 00.

1.8 WARRANTY

A. The communications cabling system, as specified in this Section, shall carry a 15-year (minimum) extended system warranty. This extended warranty shall cover parts and labor for the duration of the extended warranty. This extended warranty shall also cover electrical performance of cabling system to the specific category per ANSI/TIA-568-C performance criteria for backbone cabling.

PART 2 - PRODUCTS

2.1 UNDERGROUND CABLES – DUCT/CONDUIT

A. Application:
   1. Cable shall be suitable for underground conduit installations.
   2. Each and every cable run shall be a continuous single cable, homogenous in nature. Splices are not permitted anywhere.
   3. Cable type shall be PIC twisted pair, filled core, with an “ALPETH” sheath and compatible with Bell System type “ANAA” or RDUP type “PE89-AL”.

B. Conductors:
   1. Solid, annealed copper, 22 AWG
   2. Fully insulated conductors consisting of an inner layer of expanded polyolefin, covered with an outer layer (skin) of solid polyolefin
   3. Conductors twisted into pairs. Twisted pairs are stranded into 25-pair bundles and into units (and super units, if required by pair count)
   4. Color Coding: Twisted pairs and units (super units, if necessary) individually color-coded to industry standards (ANSI/ICEA Publication S-80-576, and EIA-230)

C. Core & Sheath:
   1. Cable core shall have a tape applied longitudinally (wrapped around its entirety)
a. Tape Material: non-hydroscopic dielectric (polypropylene) film, or equivalent

2. Cable core and sheath flooded (interstices between the pairs and under the core tape) with filling compound to protect against moisture penetration
   a. Filling compound: 80°C ETPR compound, or equivalent

3. Sheath Type: “ALPETH”. Sheath consists of a shield and an outer jacket
   a. Shield: Corrugated bare 8 mil aluminum tape applied longitudinally over the core wrap
   b. Outer Jacket: PE, black, with UV inhibitors, bonded to shield

D. Standards Compliance:
   1. Telcordia GR-421-CORE Issue 2
   2. RoHS-compliant

E. Manufacturers:
   1. General Cable
   2. Superior Essex

2.2 SPlice Closures AND ACCESSORIES

A. Splice Closure – Building Entrance Type
   1. Application: Splice closure system shall be suitable for indoor installation within an entrance facility for splicing between OSP and ISP cable.
   2. Closure:
      a. Re-enterable
      b. Through-splice or butt-splice configurations will be accepted.
      c. Solid sleeve, or split sleeve acceptable.
      d. End caps shall accept eight single collared or having multiple holes.
   3. Manufacturer:
      a. 3M Telecom Systems
         1) #5-26; solid closure, up to 600 pair,
         2) #5DS-26; split closure, up to 600 pair
         3) #C5-100-6; end caps (to be sized to cable entry and exits)
         4) #4460; shield bond connector for cables 100-pair or larger
         5) #4460-D; shield bond connector for cables 100-pair or smaller
         6) #25T ground braid or #25T ground braid with eyelets

2.3 BUILDING ENTRANCE PROTECTION

A. BEP Terminal – Swivel Stub Input, Swivel Stub Output
   1. Application: BEP terminal shall be suitable for indoor installation, within a telecom room (such as an Entrance Facility or 'MPOE'). BEP terminals shall provide termination of the backbone twisted pair cables specified within this Section, shall protect premises equipment against induced voltages and stray currents, and shall accept '5-pin' protector modules specified within this Section.
   2. Configuration: BEP terminal shall be designed for a wall-mounted configuration, and shall have the capacity to accept 100-pair incoming and outgoing pairs.
4. Manufacturer:
   a. Circa
      1) #1900A1-100; 100-pair BEP terminal with swivel stub input and output

2.4 LABELS
   A. Labels shall be machine printable with a laser printer, ink jet printer, thermal transfer printer, or hand-held printer.
   B. Labels for Cables
      1. Labels shall be adhesive-backed and have a self-laminating feature
      2. Labels shall fit the backbone cables listed above (i.e., shall fully wrap around the cable’s jacket).
      3. Printable area should be 1 inch wide x 0.5 inch high, or larger
      4. Printable area color shall be white
      5. Manufacturer:
         a. Panduit
            1) #S200X400YAJ; labels for 25 to 100 pair cables [0.32” (8.09mm) - 0.95” (24.26mm) dia.]
            2) #S200X650YAJ; labels for 100 to 400 pair cables [0.48” (12.13mm) – 1.59” (40.43mm) dia.]
         b. Or equal

2.5 DUCT PLUGS
   A. Plug shall create a watertight seal.
   B. Manufacturer:
      1. Tyco
         a. #40S136S; simplex plug for 4-inch conduit, cable OD 1.19-1.36
         b. #40S196SB; simplex plug for 4-inch conduit, cable OD 1.38-1.96
         c. #40S256SB; simplex plug for 4-inch conduit, cable OD 1.92-2.56
         d. #40S291SB; simplex plug for 4-inch conduit, cable OD 2.56-2.91
         e. #40S327SB; simplex plug for 4-inch conduit, cable OD 2.91-3.27
         f. #40B167S; “triplex” plug for 4-inch conduit, with 3 ports
         g. #40Q136S; “quadplex” plug for 4-inch conduit with 4 ports
      2. Carlon
         a. #MATPG3; “triplex” duct plug for 4-inch conduit, with 3 ports (1.53”-1.67”)
      3. Or equal

PART 3 - EXECUTION

3.1 GENERAL
   A. Comply with the Execution requirements of Section 27 00 00.
3.2 EXAMINATION AND PREPARATION

A. Rooms: Prior to installation, verify equipment rooms are suitable to accept the backbone twisted pair cables and terminations.

B. Pathways: Prior to installation verify that pathways and supporting devices, provided under other sections, are properly installed, and that temporary supports, devices, etc., have been removed. Verify dimensions of pathways, including length (for example, “True Tape” the conduits).

C. Cable Integrity: Prior to installation, verify the twisted pair cable is fully operational – both cable sheath and twisted pair conductors. Documentation of pre-installation testing is not a close out requirement, and is the responsibility of the Contractor.

3.3 INSTALLATION

A. OSP Interbuilding Backbone Cable

1. Cable runs shall have continuous sheath continuity, homogenous in nature, between either termination points or designated splices points. Only splices as noted on the Construction Documents are permitted.

2. Maximum cable length of 1,500 meters between termination points.

3. Placement

a. Place cables within designated pathways.
b. Maintain a minimum bend radius of 6 times the cable diameter during installation.
c. Maintain pulling tension within manufacturer’s limits. Only use UL approved cable-pulling compounds when necessary to reduce pulling tensions.
d. Protect cable during installation. Place and suspend cables in a manner to protect them from physical interference or damage. Place cables with no kinks, twists, or impact damage to the sheath. Replace cable if damaged during installation.
e. Neatly dress and organize cables in the cable routing facilities, and fastened to support devices via tie wraps.
f. Place a pull rope along with cables where run in conduit and spare capacity still exists in the conduit. Tie off ends of the pull rope.

4. Routing:

a. When routing horizontally within telecommunications rooms, utilize the overhead cable support; route backbone cables to avoid crossing over horizontal cabling or horizontal cabling crossing backbone cabling. When routing vertically within telecommunications rooms, utilize the vertical cable support and provide cable ties every 24 inches on center using.
b. Route cables a minimum of 6” away from power sources to reduce interference from EMI.

5. Duct Plugs

a. Provide duct plugs into each duct port in maintenance holes/pullboxes and building entrances.

6. Termination

a. Provide 15 feet cable slack loop at each end of the run. Store slack in overhead cable support or as noted on Drawings.
b. Properly strain relieve cables at designated points per manufacturer’s instructions.
c. Terminate copper pairs at both ends on the specified BEP. Perform terminations in accordance with manufacturer’s instructions and ANSI/TIA-568-C standard installation practices.

7. Labeling
a. Provide labels on each end of the cable, no more than 4" from where the cable enters the specified splice closure.
b. Place labels such that they are visible by a technician from a normal stance.

B. Building Entrance Splicing Systems
1. Provide entrance splice system as shown on the Drawings, including closure, end caps, splice modules, grounding components, and accessories required for a complete installation. Install splice closure and splice modules per manufacturer’s instructions using tools intended for the purpose.
2. Size enclosure based on splice bundle diameter, and size ends caps based on largest cable.
3. Include required accessories, such as collars, grommets, bushings, bonding connectors, etc. for a complete installation.
4. Thoroughly clean and separate binder groups prior to installing splice modules.
5. Apply sealant (such as B-sealant) to the end of the cable where the pairs exit the cable sheath – this to prevent water-blocking gel from leaking out the cable’s sheath.
6. Provide labels on each splice module and binder group in splice closure.
7. Grounding and Bonding
   a. Bond splice enclosure and cable shield to closet busbar using bonding conductor per manufacturer’s instructions and/or TIA-607 requirements.
   b. Provide 6 AWG bonding conductor up to 25 feet in length; if longer than 25 feet, size bonding conductor as 1000 circular mils per foot.
8. Fill unused end cap entry holes with appropriate plug (intended for purpose).
9. Attach splice enclosure to vertical cable runway on wall with metal straps

C. Building Entrance Protection
1. Provide BEP system as shown on the Drawings, including terminals, modules, and accessories required for a complete installation. Install BEP per manufacturer’s instructions.
2. Install BEP terminals plumb and square, and at height shown on Drawings. If no height is shown, install such that bottom row is at 24" AFF (+/- 3”).
3. Grounding and Bonding
   a. Bond BEP terminal to TMGB in accordance with NEC Article 800, and follow the installation requirements described in Article 800.
   b. Provide 6 AWG bonding conductor up to 25 feet in length; if longer than 25 feet, size bonding conductor as 1000 circular mils per foot.
4. Labeling
   a. Provide and permanently affix label on the terminal’s cover.
   b. Provide label in the label holder at the terminal’s “outgoing” connection.
5. Provide quantity of protector modules to completely populate terminals.

D. Termination Apparatus
1. Install the termination apparatus such that the bottom row of terminations is at a height as shown on the Drawings. If no height is shown, install bottom at 24” AFF (+/- 3”).
2. Provide accessories required for a complete installation.
3. Mount blocks plumb and square.

E. Crossconnects
1. In the MDF, provide one 1-pair crossconnect to length from the equipment field to the backbone field based on the records from the IDF crossconnections.
2. Utilize the horizontal and vertical management components to properly route the crossconnect wire.

3. Color:
   a. For digital handsets, provide: White-Blue / Blue-White
   b. For analog handsets, provide: White-Red / Red-White.

4. Splices in crossconnect wire are prohibited.

3.4 LABELING

A. General Requirements
   1. Labeling and identifier assignment and the label colors shall conform to the TIA/EIA-606-A Administration Standard and as approved by Owner or Owner’s Representative before installation.
   2. Provide permanent and machine-generated labels; hand written labels will not be accepted.

B. Cable Labels
   1. Label Format:
      a. Label type shall be wrap-around self-laminating.
      b. Label color shall be white background with clear laminating window.
      c. Text color shall be black; text height shall be 1/8” high, minimum, or #12 font size.
   2. Provide labels on both ends of cables. Fully wrap label around the cable jacket. Install labels no more than 4 inches from the edge of the cable jacket. Install labels such that they are visible by a technician from a normal stance.

C. Protection and Termination Apparatus Labels
   a. Use labels included in the product packaging. Request approval by the Engineer for substitutions.
   b. Label color shall be brown for respective field type, per TIA/EIA-606-A.
   c. Text color shall be black, 3/32” high, minimum, or #10 font size.

D. Identifier Assignment
   1. General: Separate label fields of the identifier with a hyphen.
   2. Cables
      a. The first field shall identify the cable type: "CBT" (for Cable, Backbone, Twisted pair).
      b. The second field shall identify the originating termination room identifier as shown on the plans; e.g., “MDF1.1”.
      c. The third field shall identify the ending termination room identifier as shown on the plans; e.g., “BDF2.1”.
      d. The fourth field shall identify the beginning and ending pair counts.
      e. Identifier Example: “CBT-MDF1.1-BDF2.1-0401-0600”
   3. Termination Positions on the BEP Terminal Cover
      a. The first field shall identify the opposite end’s room; for example “TO BDF2.1”.
      b. The second field shall identify the pair count range; for example, “0401-0500”
      c. Identifier Example: “TO BDF2.1 0401 - 0500”
3.5 FINAL INSPECTION AND CERTIFICATION

A. Punch the Work of this Section compliant to the requirements of Section 27 00 00.
B. Remove and replace with new, at no cost to the Owner, cables or conductors failing to meet the indicated standards and not passing the testing requirements of Section 27 08 11. The Owner, or Owner’s Representative, will not accept the installation until testing has indicated a 100% availability of all cables and conductors or the Owner or Owner’s Representative has approved any deviation from this requirement.
C. Comply with system acceptance and certification requirements of Section 27 00 00.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Backbone ISP (indoor) fiber optic cabling.
B. Related Sections
   1. Comply with the Related Sections paragraph of Section 27 00 00.
   2. 27 08 21 Communication Fiber Optic Testing

1.2 REFERENCES

A. Comply with References requirements of Section 27 00 00.
B. In addition to the codes and standards listed in Section 27 00 00, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. National Fire Protection Agency (NFPA)
   2. Underwriters Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
      a. UL 1659, “Metal-Clad Cables”
      b. UL 1651, “Optical Fiber Cable”
      c. UL 1666, “Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts”
   3. Insulated Cable Engineers Association (ICEA)
      b. ANSI/ICEA S-87-640-1999, “Fiber Optic Outside Plant Communications Cable”
   4. Telcordia
      a. GR-20-CORE, Issue 3, “Generic Requirements for Optical Fiber and Optical Fiber Cable”
      b. GR-409-CORE, Issue 2, “Generic Requirements for Indoor Fiber Optic Cable”

1.3 DEFINITIONS

A. Refer to Section 27 00 00 for Definitions.
B. In addition to those Definitions of Section 27 00 00, the following list of terms as used in this specification defined as follows:
   1. “MM”: Multimode [fiber type]
   2. “OFCP”: Optical Fiber Conductive Plenum, plenum rating
   3. “OFCR”: Optical Fiber Conductive Riser, non-plenum riser rating
   4. “OFNP”: Optical Fiber Non-conductive Plenum, plenum rating
5. “OFNR”: Optical Fiber Non-conductive Riser, non-plenum riser rating
6. “OFN”: Optical Fiber Non-conductive, general purpose indoor rating
7. “PVC”: PolyVinyl Chloride
8. “SM”: Singlemode [fiber type]

1.4 SYSTEM DESCRIPTION

A. Work Covered Under Other Sections
   1. Pathways: The communications pathways (backbone conduits, riser sleeves, wire mesh cable tray, cable tray, etc.) work will be covered under another Section. Refer to the drawings for size/capacity and route information.
   2. Rooms: Build out (e.g., backboards, overhead and vertical cable support, etc.) of the telecommunications rooms will be covered under another Section. Refer to the drawings for build out information.

B. Base Bid Work
   1. Provide engineering, labor, materials, apparatus, tools, equipment, and transportation required to make a complete working telecommunications backbone fiber optic cabling system installation described in these specifications and shown on related drawings.
   2. The drawings are diagrammatic in nature, and require shop drawings to complete the detailed design of the telecommunications infrastructure.
   3. Consider Backbone cabling, as shown on drawings, as base bid work, unless otherwise noted, including terminations at both ends.
   4. In general, the base bid work includes:
      a. Submittals
      b. Backbone inside plant (riser) fiber optic cables and terminations
      c. Bonding (cable armor, termination apparatus, etc)
      d. Innerduct
      e. Cable management
      f. Crossconnections / patching.
      g. Cable identification tags and system labeling
      h. Record Documents
      i. Warranty

1.5 SUBMITTALS

A. Comply with Submittal procedural, quantity, and format requirements of Section 270000.
B. Submittal Requirements Prior To Start Of Construction:
   1. Product Data Submittal, indicating conformance with NEC, UL, TIA/EIA listings, certifications and specifications.
   2. Sample Submittal, consisting of the following components:
   3. Schedule Submittal, consisting of proposed schedule of work. This schedule may be combined with the schedule developed for Division 27.
   4. Shop Drawings Submittal, consisting of proposed changes to cable routing, or termination locations/configurations
C. Submittal Requirements at Closeout:
   1. Copy of the manufacturer’s printed reel documentation, including the following.
      a. Manufacturer’s reel number
      b. Manufacturer’s traceable batch number
c. Length of the fiber cable on the reel

d. Maximum attenuation

e. Minimum bandwidth

2. As-Built Drawings
3. Crossconnection records/cut sheets
4. O&M Manuals

D. Substitutions
1. Requests for substitutions shall conform to the general requirements and procedure outlined in Section 27 00 00.

1.6 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of Section 27 00 00.

B. Contractor Qualifications
1. In addition to the Contractor Qualifications requirements of Section 27 00 00, the Contractor shall be manufacturer certified to install the proposed and submitted cabling system and to provide an extended warranty. Provide satisfactory evidence of certification in the form of a current letter or certificate from the manufacturer as part of the bid submission.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with Delivery, Storage and Handling requirements of Section 27 00 00.

1.8 WARRANTY

A. The backbone fiber optic cabling system, as specified in this section, shall carry a 15-year (minimum) extended system warranty. This extended warranty shall cover parts and labor for the duration of the extended warranty. This extended warranty shall also cover optical performance of cabling system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Corning Cable Systems (substitutions allowed)

2.2 FIBER OPTIC CABLE – NON-PLENUM RATED [REUSE EXISTING FIBER CABLE LEFT FROM THE LIBRARY BUILDING].

A. Application:
1. Cable shall be suitable for indoor installation, between floors in vertical riser system, under access flooring, and through overhead ceiling space (in basketway, cable tray, conduit, and/or hangers).
2. Optical transmission performance shall not be significantly affected by environmental fluctuations, installation, or aging.
3. Materials shall not evolve hydrogen in quantities that will increase light attenuation.

B. Multimode 50/125 μm fiber strands shall meet or exceed the following geometry criteria:
   1. Cabling to meet TIA-492-AAAD standard as specified by CCCC Infrastructure standard 2.6.
   2. Core diameter = 50 μm, ±3.0 μm
   3. Cladding diameter = 125 μm, ±1.0 μm
   4. Core/Cladding Concentricity = ≤ 3 μm
   5. Minimum Tensile Strength = 100,000 psi

C. Multimode 50/125 μm fiber strands shall meet or exceed the following performance criteria:
   1. Cabling to meet TIA-492-AAAD standard as specified by CCCC Infrastructure standard 2.6.
   2. Attenuation = 3.0 dB/km at 850 nm and 1.0 dB/km at 1300 nm wavelengths, maximum
   3. Overfilled Bandwidth = 1,500 MHz•km at 850 nm and 500 MHz•km at 1300 nm wavelengths, minimum
   4. Effective Modal Bandwidth = 2,000 MHz•km at 850 nm and 500 MHz•km at 1300 nm wavelengths, minimum

D. Singlemode fiber strands shall meet or exceed the following geometry criteria:
   1. Cabling to meet ITU-T G.652C and D as specified by CCCC Infrastructure standard 2.6.
   2. Core diameter = 8.3 μm
   3. Mode field diameter = 8.8 μm, ±0.5 μm
   4. Cladding diameter = 125 μm, ±1.0 μm
   5. Core/Cladding Concentricity = ≤ 0.8 μm
   6. Minimum Tensile Strength = 100,000 psi

E. Singlemode fiber strands shall meet or exceed the following performance criteria:
   1. Attenuation = 0.7 dB/km at 1310 nm and 0.7 dB/km at 1550 nm wavelengths, maximum
   2. Cutoff wavelength = 1260 nm
   3. Dispersion = 3.5 ps/nm•km at 1285-1330 nm and 18 ps/nm•km at 1550 nm
   4. Singlemode fiber shall meet the specifications of the following:

F. Primary Coating:
   1. Each fiber shall be completely covered with a “primary coating” (acrylate material).
   2. Coating diameter = 250 μm, ±5 μm

G. Buffering:
   1. Each coated fiber shall be fully covered with a material extruded over and directly onto the coating. This shall be the tight buffer. Tight buffer diameter = 900 μm, ±5 μm. Material = PVC, or equivalent flame retardant thermoplastic.

H. Cable Sheath:
1. **Strength Element**: The cable shall have an internal strength element such as aramid yarn (e.g., Kevlar).
2. **Outer Jacket**: The cable shall have a seamless outer jacket (material = PVC, or equivalent) applied to and completely covering the internal components (fiber strands, strength element, other).
3. **Tensile Strength**: The cable shall have a 150-lb, minimum, rated load.
4. **Flame Rating**: NEC (Article 770) rated as OFNR cable, and UL listed as such.

I. **Manufacturer**:
   1. Corning Cable Systems
   2. Or equal

### 2.3 FIBER OPTIC PATCH CORDS

A. **Application**
   1. Fiber optic patch cords shall be suitable for indoor installation within a telecommunications room within and/or between fiber patch panels.
   2. Cord shall be assembled from a single, continuous length of cordage, homogenous in nature; Splices are not permitted.

B. **Cordage – Multimode 50/125um**
   1. **Conductors**: Two 50/125um multimode tight-buffered fibers.
   2. **Strength Element**: Aramid yarn (Kevlar).
   3. **Jacket**: Flame-retardant PVC, or equivalent, in a ‘zipcord’ configuration.
   4. **NEC**: rated as OFN (or higher), and UL listed as such.

C. **Cordage – Singlemode**
   1. **Conductors**: Two singlemode tight-buffered fibers.
   2. **Strength Element**: Aramid yarn (Kevlar).
   3. **Jacket**: Flame-retardant PVC, or equivalent, in a ‘zipcord’ configuration.
   4. **NEC**: rated as OFN (or higher), and UL listed as such.

D. **Connectors**
   1. Multimode patch cords shall be either terminated via duplex LC connectors at both ends or terminated via duplex LC connectors to connect with the cable plant and via the connector type as required for connection to equipment.
   2. Singlemode patch cords shall be either terminated via duplex LC Ultra PC connectors at both ends or terminated via duplex LC-UPC connectors to connect with the cable plant and via the connector type as required for connection to equipment.

E. **Connector Loss**
   1. Multimode: \( \leq 0.5\text{dB} \) per mated pair at both 850nm and 1300nm.
   2. Singlemode: \( 0.5\text{dB} \) per mated pair at both 1310nm and 1550nm.

F. **Manufacturer**:
   1. Corning Cable Systems
   2. Or equal

### 2.4 TERMINATION APPARATUS – FIBER OPTIC PATCH PANELS
A. Application:
   1. Fiber optic patch panels shall be an enclosed housing for protecting, storing and organizing the termination of fiber cable(s) and fiber strands, shall provide means to strain relieve and support of the specified cables, shall contain facilities to store fiber slack, and shall provide patch cord management.
   2. Fiber optic patch panels shall be passive physical equipment and apparatus used in terminating, interconnecting, and cross-connecting fiber optic cabling, shall possess a minimum fire resistant rating of UL94V-1, and shall conform to existing OSHA Health and Safety Laws.
   3. Fiber optic patch panels shall be rack-mountable.

B. Fiber optic patch panels shall come equipped with safety labels such as laser identification or warning labels as required by system considerations.

C. Manufacturer:
   1. Corning Cable Systems
      a. #CCH-04U; “Connector Closet Housing” type patch panel, 4U, holds 12 adapter modules
      b. #CCH-03U; “Connector Closet Housing” type patch panel, 3U, holds 6 adapter modules
      c. #CCH-02U; “Connector Closet Housing” type patch panel, 2U, holds 4 adapter modules
      d. #CCH-01U; “Connector Closet Housing” type patch panel, 1U, holds 2 adapter modules
      e. #WCH-02P; “Wall-Mount Closet Housing” type patch panel, holds 2 adapter modules
      f. #WCH-04P; “Wall-Mount Closet Housing” type patch panel, holds 2 adapter modules
      g. #CCH-CP12-E4; Adapter Module e/w 6 duplex MM LC aqua adapters
      h. #CCH-CP12-A8; Adapter Module e/w 6 duplex MM LC beige adapters
      i. #CCH-CP12-A9; Adapter Module e/w 6 duplex SM LC blue adapters
      j. #CCH-CP06-E6; Adapter Module e/w 6 MM SC aqua adapters
      k. #CCH-CP12-E7; Adapter Module e/w 6 duplex MM SC aqua adapters
      l. #CCH-CP06-56; Adapter Module e/w 6 MM SC beige adapters
      m. #CCH-CP06-59; Adapter Module e/w 6 SM SC blue adapters
      n. #CCH-CP06-G5; Adapter Module e/w 6 MM ST aqua adapters
      o. #CCH-CP06-15T; Adapter Module e/w 6 MM ST beige adapters
      p. #CCH-CP06-19T; Adapter Module e/w 6 SM ST blue adapters
   2. Or equal

2.5 LABELS

A. Labels shall be machine printable with a laser printer, ink jet printer, thermal transfer printer, or hand-held printer.

B. Labels for Cables
   1. Labels shall be adhesive-backed and have a self-laminating feature
   2. Labels shall fit the backbone cables listed above (i.e., shall fully wrap around the cable’s jacket).
   3. Printable area should be 1 inch wide x 0.5 inch high, or larger
   4. Printable area color shall be white
   5. Manufacturer:
      a. Panduit
1)  #S200X225YAJ; labels cables 0.24" (6.06mm) - 0.48" (12.13mm) dia.
2)  #S200X400YAJ; labels for cables 0.32" (8.09mm) - 0.95" (24.26mm) dia.
3)  #S200X650YAJ; labels for cables 0.48" (12.13mm) - 1.59" (40.43mm) dia.

b. Or equal

2.6 MISCELLANEOUS

A. Fiber Slack Storage Reel: Leviton #48900-OFR, or equal
B. Velcro Cable Ties
   1. Width: .75”.
   2. Manufacturers:
      a. Panduit
         1) #HLS-15R-0 Black, 15’ roll, cut to length.
      b. Or equal

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with Execution requirements of Section 270000.

3.2 EXAMINATION AND PREPARATION

A. Pathways: Prior to installation verify pathways (conduits, etc.) and supporting devices, provided under other sections, are properly installed, and that temporary supports, devices, etc., have been removed. Verify dimensions of pathways, including length (for example, “True Tape” the conduits).
B. Rooms: Prior to installation, verify equipment rooms are ready for cables and terminations.
C. Prior to installation, verify cables and conductors are fully operational – both cable sheath and fiber strands. Pre-installation testing is the responsibility of the Contractor, though documentation of pre-installation testing is not a close out requirement.

3.3 INSTALLATION

A. Backbone Cable Installation, Routing, and Termination
   1. Cable runs shall have continuous sheath continuity, homogenous in nature. Splices are not permitted anywhere.
   2. Do not exceed 500 meters optical conductor length from the termination within the BDF to the termination in IDF.
   3. Placement
      a. Place cables within designated pathways. Place ISP cables in innerduct between points of termination throughout entire length (except at the fiber take up reel).
      b. Maintain a minimum bend radius of 20 times the cable diameter during installation, and a minimum bend radius of 10 times the cable diameter after installation.
      c. Maintain pulling tension within manufacturer's limits.
d. Place and suspend cables in a manner to protect them from physical interference or damage. Place cables with no kinks, twists, or impact damage to the sheath. Replace cables damaged during installation.

e. Do not use cable-pulling compounds for indoor installations.

f. Provide 20 to 30 feet of cable slack at each end within the Telecommunications Rooms; store slack in fiber slack storage reel mounted on the wall.

g. Place a pull rope along with cables where run in pathways and spare capacity in the pathway remains. Tie off ends of the pull rope.

4. Routing

a. When routing overhead within telecommunications rooms, neatly dress and organize cables on designated overhead cable support apparatus (for example, cable tray/runway), and fasten cables to cable support apparatus via approved straps. When routing vertically within telecommunications rooms, neatly dress and organize cables on vertical cable support apparatus (for example, vertical cable runway), and properly fasten cables to cable routing facilities via approved straps. “Properly fasten” shall consist of cable ties in a ‘crossed’ configuration per cable or cable bundle (up to three cables or innerducts) every 24 inches on center.

5. Termination

a. Properly relieve strain from cables at termination points (at/within the fiber optic termination panels) per manufacturer’s instructions.

b. Bond cable armor to grounding point (busbar) – refer to section 27 05 26 for additional information.

c. Provide breakout kits to furcate fibers from buffer tubes.

d. Terminate fiber strands via pigtail splicing at both ends using the specified fiber optic pigtail appropriate for the mode type of the fiber. Splicing type shall be fusion; mechanical splicing will not be accepted. Perform terminations in accordance with manufacturer’s instructions.

e. Provide required accessories and consumables for the complete termination of fiber strands.

f. Provide 3 feet of unsheathed fiber (tight buffer) slack within the patch panel/termination enclosure at each end of the link. Properly store fiber slack in rear of patch panel into the ‘routing rings’, per manufacturer’s instructions. Include ‘extension’ slack loop/fold in the rear of the shelf to allow for the drawer to be pulled out without putting tension on the fibers.

B. Fiber Optic Cable Termination Panel

1. Provide fully assembled termination panel in designated equipment rack; locate per drawings (if not shown, locate at the top). “Fully assembled” includes installation and mounting components and accessories such as adapter panels, coupling adapters, etc. required for operation.

2. Provide accessories required for proper installation of each termination panel, including connector panels and adapters.

3. Bond termination apparatus to grounding point (busbar) – refer to section 27 05 26 for additional information.

3.4 LABELING

A. General Requirements

1. Labeling, identifier assignment, and the label colors shall conform to the TIA/EIA-606-A Administration Standard and as approved by Owner or Owner’s Representative before installation.
2. Provide permanent and machine generated labels; hand written labels will not be accepted.

B. Cable Labels
   1. Label Format:
      a. Label type shall be wrap-around self-laminating.
      b. Label color shall be white background with clear laminating window.
      c. Text color shall be black; text height shall be 1/8" high, minimum, or #12 font size.
   2. Provide labels on both ends of cables. Fully wrap label around the cable jacket. Install labels no more than 4 inches from the edge of the cable jacket. Install labels such that they are visible by a technician from a normal stance.

C. Termination Apparatus Labels
   1. Use labels included in the product packaging. For substitutions, request approval by the Engineer.
   2. Label color shall be white for respective field type, per TIA/EIA-606-A.
   3. Text color shall be black, 3/32" high, minimum, or #10 font size.

D. Identifier Assignment
   1. General: Separate all label fields of the identifier with a hyphen.
   2. Backbone ISP Fiber Optic Cables
      a. The first field shall identify the cable type: “CBF” (for Cable, Backbone, Fiber optic).
      b. The second field shall identify the originating termination room identifier as shown on the plans; e.g., “BDF2.1”.
      c. The third field shall identify the ending termination room identifier as shown on the plans; e.g., “IDF2.2”.
      d. The fourth field shall identify the type and number of strands; for example, “Mxxx” where “M” stands for multimode and xxx stands for the ending fiber strand sequential count
      e. Identifier Example: “CBF-BDF2.1-IDF2.2-M025-M048”
   3. Termination Positions at the Termination Panels
      a. Make the first field of the identifier the destination room; for example “TO IDF2.2”.
      b. Make the second field of the identifier the strand count range; for example, “M025-M048”
      c. Identifier Example: “TO IDF2.2 M025-M048”.

3.5 FINAL INSPECTION AND CERTIFICATION

A. Punch the Work of this Section compliant to the requirements of Section 27 00 00.
B. Remove and replace with new, at no additional cost, cables with conductors failing to meet the indicated standards and not passing the testing requirements of Section 27 08 21. The Owner, or Owner’s Representative, will not accept the installation until testing has indicated a 100% availability of cables and conductors or the Owner or Owner’s Representative has approved in writing any deviation from this requirement.
C. Comply with system acceptance and certification requirements of Section 27 00 00.

END OF SECTION
SECTION 27 13 24 COMMUNICATIONS BACKBONE OSP FIBER OPTIC CABLING

PART 1 - GENERAL

1.1 SUMMARY
   A. Section Includes:
      1. Backbone outside plant (OSP) fiber optic cabling
   B. Related Sections
      1. Comply with the Related Sections paragraph of Section 270000
      2. 27 08 21 Communication Fiber Optic Testing
      3. 27 13 23 Communication Backbone ISP Fiber Optic Cabling

1.2 REFERENCES
   A. Comply with References requirements of Section 27 00 00.
   B. In addition to the codes and standards listed in Section 27 00 00, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
      1. National Fire Protection Agency (NFPA)
      2. Underwriters Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
         a. UL 1569, “Metal-Clad Cables”
         b. UL 1651, “Optical Fiber Cable”
         c. UL 1666, “Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts”
      3. Insulated Cable Engineers Association (ICEA)
         a. ANSI/ICEA S-87-640-1999, “Fiber Optic Outside Plant Communications Cable”
      4. Telcordia
         a. GR-20-CORE, Issue 3, “Generic Requirements for Optical Fiber and Optical Fiber Cable”

1.3 DEFINITIONS
   A. Refer to Section 27 00 00 for Definitions.
   B. In addition to those Definitions of Section 27 00 00, the following list of terms as used in this specification defined as follows:
      1. “HDPE”: High Density Polyethylene
      2. “LDPE”: Light Density Polyethylene
      3. “MDPE”: Medium Density Polyethylene
      4. “MM”: Multimode [fiber type]
      5. “OSP”: Outside Plant [cabling]
6. “PE”: Polyethylene
7. “SM”: Singlemode [fiber type]

1.4 SYSTEM DESCRIPTION

A. Work Covered Under Other Sections
   1. Pathways: The communications pathways (underground conduits, maintenance holes, pull boxes, innerducts, pull ropes, etc.) work will be covered under another Section. Refer to the Drawings for size/capacity and route information.
   2. Rooms: Build out (e.g., backboards, overhead and vertical cable support, etc.) of the rooms (BDFs, IDF’s) will be covered under another Section. Refer to the Drawings for build out information.

B. Base Bid Work
   1. Provide engineering, labor, materials, apparatus, tools, equipment, and transportation required to make a complete working telecommunications backbone fiber optic cabling system installation described in this Section and shown on related Drawings.
   2. The Drawings are diagrammatic in nature, and require shop drawings to complete the detailed design of the telecommunications infrastructure.
   3. Consider Backbone cabling, as shown on Drawings, as base bid work, unless otherwise noted, including terminations at both ends.
   4. In general, the base bid work includes:
      a. Submittals
      b. Backbone outside plant (OSP) fiber optic cables and terminations
      c. Bonding (cable armor, termination apparatus, etc)
      d. Innerduct
      e. Cable management
      f. Crossconnections / patching.
      g. Cable identification tags and system labeling
      h. Record Documents
      i. Warranty

1.5 SUBMITTALS

A. Comply with Submittal procedural, quantity, and format requirements of Section 270000.
B. Submittal Requirements Prior To Start Of Construction:
   1. Product Data Submittal, indicating conformance with NEC, UL, TIA/EIA listings, certifications and specifications.
   2. Sample Submittal, consisting of the following components:
      a. Cable label
   3. Schedule Submittal, consisting of proposed schedule of work. This schedule may be combined with the schedule developed for Division 27.
   4. Shop Drawings Submittal, consisting of proposed changes to cable routing, or termination locations/configurations.

C. Submittal Requirements at Closeout:
   1. Copy of the manufacturer’s printed reel documentation, including the following.
      a. Manufacturer’s reel number
      b. Manufacturer’s traceable batch number
c. Length of the fiber cable on the reel
d. Maximum attenuation
e. Minimum bandwidth

2. As-Built Drawings
3. Crossconnection records/cut sheets
4. O & M Manuals

1.6 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of Section 270000.

B. Contractor Qualifications
   1. In addition to the Contractor Qualifications requirements of Section 27 00 00, the Contractor shall be manufacturer certified to install the proposed and submitted cabling system and to provide an extended warranty. Provide satisfactory evidence of certification in the form of a current letter or certificate from the manufacturer as part of the bid submission.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with Delivery, Storage and Handling requirements of Section 27 00 00.

1.8 WARRANTY

A. The communications cabling system, as specified in this Section, shall carry a 15-year (minimum) extended system warranty. This extended warranty shall cover parts and labor for the duration of the extended warranty. This extended warranty shall also cover optical performance of cabling system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Corning Cable Systems (substitutions allowed)

2.2 SUBSTITUTIONS

A. Comply with the Substitutions requirements of Section 27 00 00.

2.3 FIBER OPTIC CABLE – UNDERGROUND DIELECTRIC

A. Application:
   1. Cable shall be suitable for outdoor installations within underground pathways system and/or within innerduct/sub-ducting.
   2. Optical transmission performance shall not be significantly affected by environmental fluctuations, installation, or aging.
   3. Materials shall not evolve hydrogen in quantities that will increase light attenuation.
B. Multimode 50/125 μm fiber strands shall meet or exceed the following geometry criteria:
   1. Cabling to meet TIA-492-AAAD standard as specified by CCCC Infrastructure standard 2.6.
   2. Core diameter = 50 μm, ±3.0 μm.
   3. Cladding diameter = 125 μm, ±1.0 μm.
   4. Core/Cladding Concentricity = ≤ 3 μm.
   5. Minimum Tensile Strength = 100,000 psi.

C. Multimode 50/125 μm fiber strands shall meet or exceed the following performance criteria:
   1. Cabling to meet TIA-492-AAAD standard as specified by CCCC Infrastructure standard 2.6.
   2. Attenuation = 3.0 dB/km at 850 nm and 1.0 dB/km at 1300 nm wavelengths, maximum.
   3. Overfilled Bandwidth = 500 MHz•km at 850 nm and 500 MHz•km at 1300 nm wavelengths, minimum.
   4. Laser Bandwidth = 2,000 MHz•km at 850 nm and 500 MHz•km at 1300 nm wavelengths, minimum.

D. Singlemode fiber strands shall meet or exceed the following geometry criteria:
   1. Cabling to meet ITU-T G.652C and D as specified by CCCC Infrastructure standard 2.6.
   2. Core diameter = 8.3 μm.
   3. Mode field diameter = 8.8 μm, ±0.5 μm.
   4. Cladding diameter = 125 μm, ±1.0 μm.
   5. Core/Cladding Concentricity = ≤ 0.8 μm.
   6. Minimum Tensile Strength = 100,000 psi.

E. Singlemode fiber strands shall meet or exceed the following performance criteria:
   1. Cabling to meet ITU-T G.652C and D as specified by CCCC Infrastructure standard 2.6.
   2. Attenuation = 0.4 dB/km at 1310 nm and 0.3 dB/km at 1550 nm wavelengths, maximum.
   3. Cutoff wavelength = 1260 nm.
   4. Dispersion = 3.5 ps/nm•km at 1285-1330 nm.
   5. Singlemode fiber shall meet the specifications of the following:

F. Buffering:
   1. Fibers shall be loosely buffered, either in a core tube or in multiple tubes around a central member.
   2. Buffer tube/tubes shall be filled with compound to protect against moisture penetration. Filling compound: “FLEXGEL”, or equivalent.

G. Sheath:
   1. Sheath shall consist of a strength member and an outer jacket, with non-metallic component dielectric sheath.
   2. Strength Member: Aramid yarn (e.g., Kevlar®), or reinforced fiberglass rods.
   3. Jacket: PE (MDPE or HDPE).
4. Rated tensile load: 600 lb. maximum rated load.
5. Operating Temperature Range: -40 to 158°F (-40 to 70°C)

H. Manufacturer:
1. Corning Cable Systems
   a. #024CW4-T4131D20; “ALTOS” gel-free sheath / outdoor cable, 24-strand 50/125μm
2. Corning Cable Systems
   a. #024SW4-T4180D20; “ALTOS” gel-free sheath / outdoor cable, 24-strand 50/125μm
3. Corning Cable Systems
   a. #024SW4-T4190D20; “ALTOS” gel-free sheath / outdoor cable, 24-strand 50/125μm
4. Corning Cable Systems
   a. #024EW4-T4101D20; “ALTOS” gel-free sheath / outdoor cable, 24-strand singlemode
5. Or equal.

2.4 SPLICING EQUIPMENT
A. Splice Closure – For Underground Vault/Pullbox
1. Splice closure shall be suitable for installation within an underground vault and/or pullbox.
2. Splice closure shall be <butt splice configuration only><through/in-line splice configuration only><branch splice configuration only><either butt, through/in-line, or branch splice configuration>.
3. Manufacturers:
   a. Corning Cable Systems
      1) #SCF-4C18-01; “Advanced Splice Closure” canister closure (butt splice configuration), 4 x 18, holds up to six 0.2” trays
      2) #SCF-4T30; “Advanced Splice Closure” in-line closure (through splice configuration), 4 x 30, holds up to six 0.2” trays
      3) #SCF-6C22-01; “Advanced Splice Closure” canister closure (butt splice configuration), 6 x 22, holds up to six 0.2” trays and one slack basket
      4) #SCF-6C22-02; “Advanced Splice Closure” canister closure (butt splice configuration), 6 x 22, holds up to twelve 0.2” trays
      5) #SCF-6T30; “Advanced Splice Closure” in-line closure (through splice configuration), 6 x 30, holds up to twelve 0.2” trays
      6) #SCF-KT-6GND; Ground kit
      7) #SCF-KT-4CBL; ‘Add-A-Cable’ kit for 4-inch closure
      8) #SCF-INSLT-BKT4; Installation bracket for 4-inch closure
      9) #SCF-KT-6CBL; ‘Add-A-Cable’ kit for 6-inch closure
     10) #SCF-INSLT-BKT; Installation bracket for 6-inch closure
     11) #M67-041; 0.2” splice tray, holds 12 bare fusion splices
     12) #M67-092; 0.2” splice tray, holds 24 bare fusion splices
     13) #M67-048; 0.2” splice tray, holds 12 heat shrink fusion splices
     14) #M67-031; 0.2” splice tray, holds 12 CamSplice mechanical splices
     15) #SCF-ST-099; 0.2” splice tray
b. 3M Telcom
   1) # 2178-LS large splice case
   2) #2522 organizer

c. PLP / Preformed Line Products:
   1) #80805105; “COYOTE” splice closure
   2) #8003509 60mm heat shrink organizer

d. Or equal.

B. Mechanical Splice Module

1. Mechanical splice module shall be suitable for installation within a splice closure either an
   underground vault/pullbox or within a building entrance facility.

2. Mechanical splice module shall accept both 250 μm primary coated (from loose buffer)
   fibers and 900 μm tight buffered fibers.

3. Mechanical splice module filled with index matching gel.

4. Performance:
   a. Maximum Insertion Loss – both multimode and singlemode: <0.3 dB.
   b. Maximum Reflection – both multimode and singlemode: <45dB.

5. Manufacturer:
   a. Corning Cable Systems
      1) #95-000-04; CamSplice mechanical splice module

B. Mechanical Splice Module

A. Application:

1. Fiber optic patch panels shall be an enclosed housing for protecting, storing and
   organizing the termination of fiber cable(s) and fiber strands, shall provide means to
   strain relieve and support of the specified cables, shall contain facilities to store fiber
   slack, and shall provide patch cord management.

2. Fiber optic patch panels shall be passive physical equipment and apparatus used in
   terminating, interconnecting, and cross-connecting fiber optic cabling, shall possess a
   minimum fire resistant rating of UL94V-1, and shall conform to existing OSHA Health and
   Safety Laws.

3. Fiber optic patch panels shall be <rack-mountable.

B. Fiber optic patch panels shall come equipped with safety labels such as laser identification or
   warning labels as required by system considerations.

C. Manufacturer:

1. Corning Cable Systems
   a. #CCH-04U; “Connector Closet Housing” type patch panel, 4U, holds 12 adapter
      modules
   b. #CCH-03U; “Connector Closet Housing” type patch panel, 3U, holds 6 adapter
      modules
   c. #CCH-02U; “Connector Closet Housing” type patch panel, 2U, holds 4 adapter
      modules
   d. #CCH-01U; “Connector Closet Housing” type patch panel, 1U, holds 2 adapter
      modules
2. Or equal.

2.6 FIBER OPTIC CONNECTORS

A. Multimode Fiber Optic Connectors – LC Type

1. Materials:
   a. Ferrule: ceramic with pre-radiused finish/face
   b. Connector Housing: Plastic

2. Connector shall have an integral strain relief feature, including a bend limiting rear boot.

3. Connector shall be installable via either epoxy or anaerobic method.

4. Manufacturer:
   a. SYSTIMAX
      1) #P1001A-Z-125 (700 007 008); LC type connector, MM, zirconia ceramic, beige boot, for 0.9 mm buffered fiber
      2) #P1001A-Z-125R (760 034 181); LC type connector, MM, pre-radius zirconia ceramic, beige boot, for 0.9 mm buffered fiber
   b. Corning Cable Systems
      1) #95-051-98-SP; LC type connector, ceramic ferrule, for 50/125 μm MM, aqua boot
   c. Panduit
      1) #FLCSMEIY; LC type connector, zirconia ceramic, MM, elec ivory

B. Singlemode Fiber Optic Connectors – LC Type

1. Materials:
   a. Ferrule: ceramic (zirconia or alumina) with pre-radiused finish/face
   b. Connector housing: plastic

2. Connector shall have an integral strain relief feature, including a bend limiting rear boot.

3. Connector shall be installable via either epoxy or anaerobic method.

4. Manufacturer:
   a. SYSTIMAX
      1) #P1101A-Z-125 (700 011 372); LC type connector, SM, zirconia ceramic, blue boot, for 0.9 mm buffered fiber
2) #P1101A-Z-125R (760 034 199); LC type connector, SM, pre-radius zirconia ceramic, blue boot, for 0.9 mm buffered fiber

b. Corning Cable Systems
1) #95-201-98-SP; LC type connector, ceramic ferrule, SM, blue boot

c. Panduit
1) #FLCSSBUY; LC type connector, zirconia ceramic, SM, blue

2.7 LABELS

A. Labels shall be machine printable with a laser printer, ink jet printer, thermal transfer printer, or hand-held printer.

B. Labels for Cables
1. Labels shall be adhesive-backed and have a self-laminating feature
2. Labels shall fit the backbone cables listed above (i.e., shall fully wrap around the cable’s jacket).
3. Printable area should be 1 inch wide x 0.5 inch high, or larger
4. Printable area color shall be white
5. Manufacturer:
   a. Panduit
      1) #S200X225YAJ; labels cables 0.24” (6.06mm) - 0.48” (12.13mm) dia.
      2) #S200X400YAJ; labels for cables 0.32” (8.09mm) - 0.95” (24.26mm) dia.
      3) #S200X650YAJ; labels for cables 0.48” (12.13mm) - 1.59” (40.43mm) dia.
   b. Or equal

2.8 MISCELLANEOUS

A. Breakout Kits
1. Application: for loose buffer cables, kit to furcate coated fibers from buffer tube in preparation for “direct connectorization” type termination.
2. Manufacturer:
   a. Corning Cable Systems
      1) #FAN-BT25-06; “Buffer Tube Fan-Out Kit”, for 6 fibers/tube, 25” tubing
      2) #FAN-BT36-06; “Buffer Tube Fan-Out Kit”, for 6 fibers/tube, 36” tubing
      3) #FAN-BT47-06; “Buffer Tube Fan-Out Kit”, for 6 fibers/tube, 47” tubing
      4) #FAN-BT25-12; “Buffer Tube Fan-Out Kit”, for 12 fibers/tube, 25” tubing
      5) #FAN-BT36-12; “Buffer Tube Fan-Out Kit”, for 12 fibers/tube, 36” tubing
      6) #FAN-BT47-12; “Buffer Tube Fan-Out Kit”, for 12 fibers/tube, 47” tubing
   b. SYSTIMAX
      1) #760 018 820; breakout kit for 6 strands per tube
      2) #760 018 838; breakout kit for 12 strands per tube
   c. Or equal

B. Fiber Slack Storage Reel: Leviton #48900-OFR, or equal

C. Velcro Cable Ties
1. Width: .75”.
2. Manufacturers:
PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the Execution requirements of Section 270000.

3.2 EXAMINATION AND PREPARATION

A. Pathways: Prior to installation verify that duct banks, ducts, maintenance holes, pullboxes, and supporting devices, provided under other sections, are properly installed, and that temporary supports, devices, etc., have been removed. Verify dimensions of pathways, including length (for example, “True Tape” the conduits).

B. Rooms: Prior to installation, verify equipment rooms are ready for cables and terminations.

C. Prior to installation, verify cables and conductors are fully operational – both cable sheath and fiber strands. Pre-installation testing is the responsibility of the Contractor, though documentation of pre-installation testing is not a close out requirement.

3.3 INSTALLATION

A. Backbone Cable Installation and Routing

1. Cable runs shall have continuous sheath continuity, homogenous in nature. Splices are not permitted anywhere, unless expressly shown on the Drawings or approved in writing by the Engineer prior to installation.

2. Do not exceed 1,500 meters optical conductor length from the termination within the BDF to the termination in the IDF.

3. Placement

a. Install cables within designated pathways. Place OSP cables in innerduct between points of termination throughout entire length (except at the fiber take up reel).

b. Maintain a minimum bend radius of 20 times the cable diameter during installation, and a minimum bend radius of 10 times the cable diameter after installation.

c. Maintain pulling tension within manufacturer’s limits. Use a pulling tension meter when using mechanical assistance during installation. Record maximum pulling tension for each cable run, and submit to the Engineer for review if requested. Replace runs when manufacturer’s maximum pulling tension is exceeded.

d. Place and suspend cables in a manner to protect them from physical interference or damage. Place cables with no kinks, twists, or impact damage to the sheath. Replace cables damaged during installation.

e. Only use UL approved cable-pulling compounds when necessary to reduce pulling tensions.

f. Provide 20 to 30 feet (minimum) cable slack at each end within the Telecommunications Rooms; store slack in fiber slack storage reel mounted on the wall.

g. Place a pull rope along with cables where run in pathways (e.g., conduit) and spare capacity in the pathway remains. Tie off ends of the pull rope.
a. Neatly dress and organize cables using designated cable routing facilities, and fasten to support devices via tie wraps or Velcro-type straps.

b. When routing overhead within Telecommunications Rooms, neatly dress and organize cables on designated cable support apparatus (for example, cable tray/runway), and fasten cables to cable support apparatus via tie wraps or Velcro-type straps. When routing vertically within Telecommunications Rooms, neatly dress and organize cables on vertical cable support apparatus (for example, vertical cable runway), and properly fasten cables to cable routing facilities via tie wraps or Velcro-type straps. “Properly fasten” shall consist of cable ties in a ‘crossed’ configuration per cable or cable bundle (up to three cables or innerducts) every 24 inches on center.

5. Termination

a. Properly relieve strain from cables at termination points (at/within the fiber optic termination panels) per manufacturer’s instructions.

b. Bond cable armor to grounding point (busbar) – refer to section 270526 for additional information.

c. Provide breakout kits to furcate fibers from buffer tubes.

d. Terminate fiber strands via pigtail splicing at both ends using the specified fiber optic pigtail appropriate for the mode type of the fiber. Splicing type shall be fusion; mechanical splicing will not be accepted. Perform terminations in accordance with manufacturer’s instructions.

e. Provide required accessories and consumables for complete termination of fiber strands.

f. Provide 3 feet of unsheathed fiber (including buffer tube and broken out from the buffer tube) slack within the patch panel/termination enclosure at each end of the link. Properly store fiber slack in rear of patch panel into the ‘routing rings’, per manufacturer’s instructions.

B. Fiber Optic Cable Termination Panel

1. Provide fully assembled termination panel in designated equipment rack; locate per Drawings (if not shown, locate at the top). “Fully assembled” includes installation and mounting components and accessories such as adapter panels, coupling adapters, etc. required for operation.

2. Provide accessories required for proper installation of each termination panel, including connector panels and adapters.

3. Bond termination apparatus to grounding point (busbar) – refer to section 270526 for additional information.

3.4 LABELING

A. General Requirements

1. Labeling, identifier assignment, and the label colors shall conform to the TIA/EIA-606-A Administration Standard and as approved by Owner or Owner’s Representative before installation.

2. Provide permanent and machine generated labels; hand written labels will not be accepted.

B. Cable Labels

1. Label Format:

   a. Label type shall be wrap-around self-laminating.

   b. Label color shall be white background with clear laminating window.
c. Text color shall be black; text height shall be 1/8” high, minimum, or #12 font size.

2. Provide labels on both ends of cables. Fully wrap label around the cable jacket. Install labels no more than 4 inches from the edge of the cable jacket. Install labels such that they are visible by a technician from a normal stance.

C. Termination Apparatus Labels
   1. Use labels included in the product packaging. For substitutions, request approval by the Engineer.
   2. Label color shall be brown, white, and/or grey for respective field type, per TIA/EIA-606-A.
   3. Text color shall be black, 3/32” high, minimum, or #10 font size.

D. Identifier Assignment
   1. General: Separate all label fields of the identifier with a hyphen.
   2. Backbone OSP Fiber Optic Cables
      a. The first field shall identify the cable type: “CBF” (for Cable, Backbone, Fiber optic).
      b. The second field shall identify the originating termination room identifier as shown on the plans; e.g., “MDFA.1”.
      c. The third field shall identify the ending termination room identifier as shown on the plans; e.g., “BDF1.1”.
      d. The fourth field shall identify the type and number of strands; for example, “Mxxx” where “M” stands for multimode and xxx stands for the ending fiber strand sequential count.
      e. Identifier Example: “CBF-MDFA.1-BDF1.1-M145-M192”
   3. Termination Positions at the Termination Panels
      a. Make the first field of the identifier the destination room; for example “TO IDF2.2”.
      b. Make the second field of the identifier the strand count range; for example, “M025-M048”
      c. Identifier Example: “TO BDF1.1 M145-M192”.

3.5 FINAL INSPECTION AND CERTIFICATION

A. Punch the Work of this Section compliant to the requirements of Section 27 00 00.
B. Remove and replace with new, at no cost to the Owner, cables or conductors failing to meet the indicated standards and not passing the testing requirements of Section 27 08 21. The Owner, or Owner's Representative, will not accept the installation until testing has indicated a 100% availability of all cables and conductors or the Owner or Owner's Representative has approved any deviation from this requirement.

Comply with system acceptance and certification requirements of Section 27 00 00.END OF SECTION
SECTION 27 15 13 COMMUNICATIONS HORIZONTAL TWISTED PAIR CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Horizontal Twisted Pair Cabling (subsystem of Telecommunications Cabling Infrastructure)
B. Related Sections
   1. Comply with the Related Sections requirements of Section 27 00 00
   2. Section 27 08 11, “Communication Twisted Pair Testing”
   3. Section 27 13 13, “Communication Backbone Twisted Pair Cabling”

1.2 REFERENCES

A. Comply with the References requirements of Section 27 00 00.
B. In addition to the codes and standards listed in Section 27 00 00, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. National Fire Protection Agency (NFPA)
   2. Underwriters Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
      a. UL 444, “Communications Cables”
      b. UL 497, “Protectors for Paired-Conductor Communication Circuits”
      c. UL 1581, “Reference Standard for Electrical Wires, Cables, and Flexible Cords”
      d. UL 1666, “Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts”
      e. UL 1863, “Communications-Circuit Accessories”
      f. UL 2024A, “Optical Fiber Cable Routing Assemblies”
   3. Insulated Cable Engineers Association (ICEA):
      a. ANSI/ICEA S-90-661-2008, “Category 3, 5, and 5e Individually Unshielded Twisted Pair Indoor Cable for Use In General Purpose and LAN Communication Wiring Systems”
   4. Telcordia
      a. GR-111, “Generic Requirements for Thermoplastic Insulated Riser Cable”

1.3 DEFINITIONS
A. Refer to Section 27 00 00 for Definitions.

B. In addition, define the following list of terms as used in this specification as follows:

2. “Channel”: End to end transmission path; e.g., the entire portion of the horizontal cabling to each outlet consisting of the Permanent Link, line cord (at the workstation), patch cord, and, if a full crossconnection is implemented, the crossconnect termination/connecting apparatus and equipment cord.
3. “CMP”: Communications Media Plenum [NEC plenum rating]
4. “CMR”: Communications Media Riser [NEC riser {non-plenum} rating]
5. “FEP”: Fluorinated Ethylene Propylene
6. “FTP”: Foiled Twisted Pair
7. “PE”: Polyethylene
8. “Permanent Link”: Test configuration for a horizontal cabling link excluding patch cords, equipment cords, and line cords; e.g., the ‘permanent’ portion of the horizontal cabling to each outlet consisting of cable, consolidation point (if used), termination/connecting apparatus in the telecommunications and the connector at the outlet.
9. “PVC”: PolyVinyl Chloride
10. “UTP”: Unshielded Twisted Pair

1.4 SYSTEM DESCRIPTION

A. Work Covered Under Other Sections

1. Pathways: The communications pathways (basketway, conduits, stubs, etc.) work will be covered under another Section. Refer to the contract drawings for size/capacity and route information.
2. Rooms: Build out (e.g., backboards, overhead and vertical cable runway, etc.) of the telecommunications rooms will be covered under another Section. Refer to the contract drawings for build out information.
3. Connecting Media: Patch cords in the IDF’s between horizontal field and network equipment (e.g., access switch), patch/line cords at the work areas between outlet and user equipment (e.g., phone, computer, etc)

B. Base Bid Work

1. Provide engineering, labor, materials, apparatus, tools, equipment, and transportation required to make a complete working communications Horizontal Twisted Pair Cabling System installation described in this Section and shown on related drawings. Consider Horizontal Cabling as shown on contract drawings as base bid work, unless otherwise noted. This includes terminations at both ends.
2. In general, the base bid work includes:
   a. Submittals
   b. Horizontal cables, terminations, and outlets
   c. Cable management
   d. Patch cords and crossconnections
   e. Cable identification tags and system labeling
   f. Record Documents
   g. Warranty

C. Jack Wiring: T568A per CCCC Infrastructure standard 2.6.

1.5 SUBMITTALS
A. Comply with the Submittals article of Section 270000 for procedural, quantity, content, and format requirements.

B. Substitutions
   1. Conform to substitutions requirements and procedure in Section 270000.

C. Submittal Requirements at Start Of Construction:
   1. Product Data Submittal, indicating conformance with NEC, UL, TIA/EIA listings, certifications and specifications.
   2. Sample Submittal, consisting of the following components:
      a. Type “A” Outlet Sample – one fully configured outlet including faceplate, modular jacks, and label
      b. Cable Label Sample
   3. Schedule Submittal, consisting of proposed schedule of work. This schedule may be combined with the schedule developed for 27xxxx series Sections
   4. Shop Drawings Submittal, consisting of proposed changes to cable routing, or termination locations/configurations

D. Submittal Requirements at Closeout:
   1. As-Built Drawings
   2. Cable ID –to– Office Number Key: Submit a “cable ID-to-Office number key” as an electronic file in an MS-Excel spreadsheet file format containing a list of every cable identifier associated with the final office number
   3. Crossconnection records/cut sheets
   4. O & M Manuals

E. Posted Documentation
   1. Post one full size plot of as-built drawings, specifically the floor plans and (as applicable) reflected ceiling plans, within TRs such that show the TR’s serving area. Coordinate location with Owner.

1.6 QUALITY ASSURANCE

A. Comply with Quality Assurance requirements of Section 270000.

B. Contractor Qualifications
   1. In addition to the Contractor Qualifications requirements of Section 27 00 00, the Contractor shall be certified by the manufacturer to provide the cabling system (proposed, submitted, and approved) and to provide an extended warranty. Submit satisfactory evidence of certification in the form of a current letter or certificate from the manufacturer as part of the bid.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with the Delivery, Storage and Handling requirements of Section 27 00 00.

1.8 WARRANTY
A. The horizontal cabling system, as specified in this section, shall carry a 15-year (minimum) extended system warranty. This extended warranty shall cover parts and labor for the duration of the extended warranty. This extended warranty shall also cover electrical performance of cabling system to the specific category per ANSI/TIA/EIA-568-C performance criteria for horizontal cabling.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. CommScope SYSTIMAX cabling system
B. Panduit cabling system
C. Berk-Tek (cable) and Leviton (connectivity) cabling system
D. Belden cabling system
E. Superior Essex cabling system

2.2 SUBSTITUTIONS

A. Comply with the Substitutions requirements of Section 27 00 00.

2.3 HORIZONTAL CABLE – CAT6A PLENUM (CMP) RATED

A. Application: Suitable for indoor installation, within ceiling space in primary and secondary pathways, within access/raised floor space.
B. Conductors:
   1. Insulated Conductors: 23 AWG solid copper, fully insulated with a flame retardant thermoplastic material (material = FEP, or equivalent).
C. Cable Sheath:
   1. Outer Jacket: seamless outer jacket (material = LS-PVC, or similar) applied to and completely cover the internal components (twisted pairs).
   2. Flame Rating: NEC (Article 800) rated as CMP, and UL listed as such.
D. Electrical Performance: Meet or exceed TIA/EIA-568-C.2, ISO 11801 Class E Edition 2.1, and IEEE Std. 802.3an channel requirements for supporting 10GBASE-T.

2.4 TERMINATION APPARATUS – MODULAR PATCH PANEL, CAT6A RATED

A. Application: Panels shall be suitable for installation within a telecommunication room (IDF) for the termination of the horizontal cables specified herein. Panels shall be horizontally oriented for a rack-mounted configuration. Panels shall be capable of supporting, organizing, labeling and patching/ crossconnecting between the horizontal termination field and the equipment termination field.
B. Mechanical Performance: Each port shall be an 8-position modular jack, compliant to ANSI/TIA-568-C.2 (2.5.7).
C. Electrical Performance: Each port shall meet or exceed TIA/EIA-568-C.2 6.8 and ISO/IEC 11801 requirements for CAT6A UTP cabling through the cable termination and patch cord connection.

D. Manufacturer:
   1. Belden
      a. #AX103256; CAT6A modular patch panel “10GX”, flat, 48 ports, preloaded with 48 KeyConnect jacks
   2. CommScope
      a. #M2000-2U; Modular patch panel for “GigaSPEED X10D”, 48 ports
   3. Leviton
      a. #6A586-U48; CAT6A modular patch panel “eXtreme 6A”, flat, 48 ports
   4. Ortronics
      a. #OR-PHD610U48; CAT6A modular patch panel “Clarity10G”, flat, 48 ports
   5. Panduit
      a. #DP486X88TGY; CAT6A modular patch panel “DP6 10Gig”, flat, 48 ports
   6. Or equal

2.5 MODULAR CONNECTOR / 8-POSITION JACK – CAT6A RATED

A. Application: Modular connectors (jacks) for termination of 4-pair UTP cables; modular connectors shall be compatible with the 4-pair cables specified herein this section both electrically and physically.

B. Mechanical Performance: Modular jacks shall be 8-position, compliant to ANSI/TIA-568-C.2.

C. Electrical Performance: Each jack shall meet or exceed TIA/EIA-568-C.2 and ISO/IEC 11801 requirements for CAT6A UTP cabling.

D. Manufacturer:
   1. Belden
      a. #AX104156; CAT6A 8-position “10GX KeyConnect” jack, blue
      b. #AX102282; CAT6A 8-position “10GX KeyConnect” jack, white
   2. CommScope
      a. #MGS500BH-318; CAT6A 8-position “GigaSpeed X10D” jack, blue
      b. #MGS500BH-262; CAT6A 8-position “GigaSpeed X10D” jack, white
   3. Leviton
   4. Panduit

2.6 WORK AREA OUTLETS

A. Faceplates for Standard Flush-Mount Outlets
   1. Application: Faceplates shall be suitable for indoor installation for standard 1-gang and 2-gang flush-mount devices.
   2. Faceplates shall have 2, 3, 4, or 6 ports, and shall include required accessories, such as icons, blank inserts, label windows and labels.
4. Manufacturer:
   a. Belden
   b. CommScope
   c. Leviton
   e. Ortronics

A. Labels shall be machine printable with a laser printer, ink jet printer, thermal transfer printer, or hand-held printer.

B. Labels for Horizontal Cables
   1. Adhesive backed labels and self-laminating feature.
   2. Fit the horizontal cables listed above (i.e., shall fully wrap around the cable’s jacket).
   3. Size: 2"x.05" printable area, minimum
   4. Color: Per CCCC Infrastructure Standard 2.6, Color Coding standard for patch cables and jacks:
      a. Voice - white cable and jacks
      b. Data in Administrative Areas and Offices - blue cable and jacks
      c. Data in Instructional Areas - yellow cable and jacks
      d. Emergency Speakers – orange cable and jacks
      e. Wireless Access Points - green cable and jacks
      f. Security – black cable and jacks

5. Manufacturer:
   a. Panduit
      1) #S100X150YAJ; labels for cable diameters 0.16"-0.32", white, desktop printer (laser or ink jet)
   b. Or equal

2.8 MISCELLANEOUS COMPONENTS

A. Velcro Cable Ties
   1. Width: .75".
   2. Manufacturers:
      a. Panduit “Tak-Ty” series cable ties
      b. Panduit
         1) #HLS-15R-0; black, 15’ roll, cut to length.
      c. Or Equal

B. Plenum Cable Ties
   1. Application: for use in plenum or air handling spaces
   2. Color: maroon or other distinctive non-white color
   3. Manufacturer:
      a. Panduit
         1) #PLT1M-xxxx
         2) #PLT2S-xxxx
         3) #PLT3S-xxxx
      b. Or equal.
PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the Execution requirements of Section 27 00 00.

3.2 EXAMINATION AND PREPARATION

A. Rooms: Prior to installation, verify equipment rooms are suitable to accept the horizontal cables and terminations.
B. Pathways: Prior to installation verify that pathways and supporting devices, provided under other sections, are properly installed, and that temporary supports, devices, etc., have been removed. Verify dimensions of pathways, including length (for example, “True Tape” the conduits).
C. Cable Integrity: Prior to installation, verify the cable’s integrity – both sheath and conductors. Documentation of pre-installation testing is not a close out requirement, and is the responsibility of the Contractor.

3.3 INSTALLATION

A. Cable Installation and Routing
   1. Cable runs shall have continuous sheath continuity, homogenous in nature. Splices are not permitted anywhere.
   2. Place cables within designated pathways, such as cable tray, basketway, cable hangers, etc. Do no fasten (such as with cable ties) or attach cables to other building infrastructure (such as ducts, pipes, conduits, etc), other systems (such as ceiling support wires, wall studs, etc), or to the outside of conduits, cable trays, or other non-approved pathway systems.
   3. Place and suspend cables and conductors during installation and termination in a manner to protect them from physical interference or damage. Place cables with no kinks, twists, or impact damage to the sheath. Replace cables damaged during installation or termination at no additional cost.
   4. Maintain minimum cable length of 15 meters from the termination in the IDF to the termination at the user’s faceplate (permanent link).
   5. No cable length shall exceed 90 meters from the termination point in the IDF to the termination point at the work area (permanent link).
   6. Route cables at 90-degree angles, allowing for bending radius, along corridors for ease of access.
   7. Do not exceed manufacturer’s limits for pulling tension.
   8. Do not use cable-pulling compounds for indoor installations.
   9. Maintain a minimum bend radius of 6 times the cable diameter during and after installation.
   10. Route cables under building infrastructure (such as ducts, pipes, conduits, etc); Do not route cables over building infrastructure. The installation shall result in easy accessibility to the cables in the future.
   11. Place cables 6”, minimum, away from power sources to reduce interference from EMI.
   12. Place a pull string along with cables where run in pathways and spare capacity in the pathway remains. Tie off ends of the pull string (to prevent the string from falling into the conduit).
   13. Neatly dress and organize cables using designated cable routing facilities, and fasten to support devices via tie wraps or Velcro-type straps.
14. When exiting the primary pathway (such as basketway or cable tray) to the work area, exit via the top of the pathway. Secure the cables to the pathway using an approved cable tie.

B. Cable Routing and Dressing within the IDF
1. Place cables within the overhead cable support and, when routing vertically, fasten the cables onto wall-mounted vertical cable support every 24 inches on-center using cable ties.
2. At the rack bay, route cables into the back of the vertical management sections (do not route cables into the front as this space is reserved for patch cords only). Divide the cables equally between both sides of an equipment rack such that a cable does not travel past the midpoint of the rack prior to termination. Dress and cut cables to length required to reach the designated termination point with no excess cable and slack left in the horizontal cable manager, vertical cable manager, and overhead cable support.
3. Provide 10-15 feet, minimum, sheathed cable slack – length not to exceed permanent link maximum length requirement. Place the slack in the overhead cable support.

C. Termination in the IDF
1. Provide termination apparatus and accessories required for a complete installation. Install and assemble termination apparatus, accessories and associated management apparatus according to the manufacturer’s instructions.
2. Cables must terminate in a data room (TR) on the same floor
3. Properly strain relieve cables to and at termination points per manufacturer’s instructions.
4. Terminate cables and twisted pairs in accordance with manufacturer's latest installation requirements and ANSI/TIA-568-C.0 standard installation practices. Terminate cable pairs onto the termination apparatus. Terminate twisted pairs compliant to ANSI/TIA-568-C.0 and wired per 1.04 System Description.
5. Modular Patch Panels and Horizontal Management Panels
   a. Provide quantity of modular patch panels to support termination of cables served from respective IDF. Provide quantity of horizontal management panels based on the quantity of patch panels.
   b. Install and assemble modular patch panels and horizontal management panels according to the manufacturer’s instructions.
   c. Install the patch panels and the horizontal management panels as shown on the contract drawings. If configuration is not shown, install the patch panels in association with the horizontal management panels such that a management panel is mounted above and below given patch panel.

D. Cable Routing and Dressing at the Work Areas
1. Provide 2-4 feet, minimum, sheathed cable slack – length not to exceed permanent link maximum length requirement. Place the slack within ceiling space neatly on a cable hanger.

E. Termination at the Work Areas
1. Provide device components, connectors, and accessories required for a complete installation. Install and assemble connectors, jacks, adapters, termination apparatus, accessories and associated management apparatus according to the manufacturer’s instructions.
2. Provide six inches, minimum, sheathed cable slack behind each workstation outlet faceplate. Coil the slack cable inside the raceway, within the wall, or in the junction box (if used), per the cabling manufacturer's installation standards.
3. Type “A” Wall-Mount Faceplates
a. Install devices at heights shown on the contract drawings. If no heights are shown, install at 24" AFF on center (+/- 3").
b. Mount faceplates plumb, square, and at the same level as adjacent device faceplates.
c. Patch gaps around faceplates so that faceplate covers the entire opening.

4. Type “C” Furniture-Mount Faceplates
   a. Coordinate installation of faceplate adapters with the furniture contractor, including color.
   b. Mount faceplate adapters into the designated opening for telecommunications cabling.

5. Terminate cables and twisted pairs in accordance with manufacturer’s latest installation requirements and ANSI/TIA-568-C.0 standard installation practices. Terminate twisted pairs compliant to ANSI/TIA-568-C.0 and wired per 1.04 System Description.

3.4 LABELING

A. General Requirements
   1. Labeling, identifier assignment, and label colors shall conform to ANSI/TIA/EIA-606-A Administration Standard and as approved by the Owner before installation.
   2. Permanent labels with machine-generated text (hand written labels will not be accepted).

B. Label Formats
   1. Horizontal Cable Labels
      a. Text Attributes: Black, 1/8" high, minimum, or #12 font size.
      b. Install labels on both ends of cables no more than 4" from the edge of the cable jacket. Install labels such that they are visible by a technician from a normal stance.
   2. Patch Panel Labels
      a. Use modular patch panel labels included in the product packaging. Request approval by the Engineer for other labels.
      b. Use a label color for the respective field type, per TIA/EIA-606.
      c. Text Attributes: Black, 3/32" high, minimum, or #10 font size.
   3. Termination Block Labels
      a. Use labels included in the product packaging. Any deviation from this requirement must be approved in writing by the Owner.
      b. Use a label color for the respective field type, per TIA/EIA-606-A.
      c. Text Attributes: Black, 3/32" high, minimum, or #10 font size.
   4. Outlet Labels
      a. Use outlet labels included in the product packaging. Any deviation from this requirement must be approved in writing by the Owner.
      b. Label Background: White.
      c. Text Attributes: Black, 1/8" high, minimum, or #12 font size.
      d. Install label in the top label window. Leave the bottom label window blank.

C. Identifier Assignment
   1. General: Separate label fields of the identifier with a hyphen.
   2. Horizontal Cables
a. Refer to drawings.

3. Outlets
   a. Refer to drawings.

4. Individual Ports at the Outlets
   a. Refer to drawings.

5. Individual Termination Positions at Termination Blocks
   a. Refer to drawings.

6. Individual Ports at Patch Panels
   a. Coordinate colors and function requirements with owner prior to final installation.

3.5 FINAL INSPECTION AND CERTIFICATION

A. Punch the Work of this Section compliant to the requirements of Section 270000.
B. Remove cables and replace with new those failing to meet the indicated standards and not passing the testing requirements of Section 270811 with no impact to cost and schedule. The Owner, will not accept the installation until testing has indicated a 100% availability of all cables and conductors. Any deviation from this requirement must be approved in writing by the Owner.
C. Comply with system acceptance and certification requirements of Section 270000.

END OF SECTION
SECTION 272310 - INSTRUCTIONAL PLANETARIUM MEDIA SYSTEMS (IPMS)

PART 1 – GENERAL

1.1 PROJECT DESCRIPTION/WORK INCLUDED

A. Please refer to diagrammatic and schematic level drawings A.1 PL, AV1. BLOCK DRAWING, A1.CONSOLE, and TE1.PL. as well as attached specified equipment cut sheets. The selected contractor shall provide, install, train for, and support the following instructional media systems (IPMS):

1. INSET DOME PROJECTION SYSTEM. WUXGA projector produces a partial dome projection app. 8’ high x 16’ wide.

Specified Model: Panasonic PT-EZ770 with mount attached to dome tension ring

2. ULTRA-SHORT THROW PROJECTION SYSTEM. This is an Ultra Short-Throw (0.23 ratio) Projector for roll-down screen. Native Resolution is 1920 x 1080.

Specified Model: Viewsonic LS830 with wall mount PJ-WMK-304 Universal Wall Mount Kit

3. Two (2) 65” wall-mounted monitors

Specified Model: Panasonic TH-65SF2U

4. Roll-down electric screen for 52” x 92” (16:9) image

Specified Model: DA-LITE Tensioned Advantage Deluxe Electrol screen- DaMat surface -52” x 92”

5. 6 IN/4 OUT MEDIA MATRIX/ROUTING SWITCHER - for distributing six video/data sources with four outputs

Specified Model: Crestron DM-MD6X4

B. The Planetarium takes the form of multi-use domed theater and, in addition to astronomy, is also used for general instruction/lecture and visualization by various College Departments including: Science, Engineering, and Math.

C. Unless otherwise noted, a substituted component may be proposed and included, but only if approved in advance by the Planetarium Design Consultant and/or the Contra Costa College.

D. This specification shall apply to all phases of Work hereinafter specified, shown on drawing, or as required to provide a complete installation. Work required under this specification, is not limited to just the (IPMS) - refer to Architectural, Electrical, Structural, and Raceway/Structural Cabling, as well as all other drawing applicable to this project, which designate the scope of work to be accomplished. The intent of the drawings and Specifications is to provide a complete and operable planetarium system that includes all documents that are a part of the Contract.

1. Work Included. Furnish labor, material, services and skilled supervision necessary for the construction, erection, installation, connections, testing, and adjustment of all IPMS equipment specified herein, or shown or noted on drawings, and its delivery to the Owner complete in all respects ready for use.
2. The IPMS work includes installation or connection of certain materials and equipment furnished by others. Verify installation details, installation and rough-in locations from the actual equipment or from the equipment shop drawings.

E. The associated system drawings are diagrammatic and are intended to convey the scope of work, indicating intended general arrangement of equipment. Follow drawings in laying out work and verify spaces for installation of materials and equipment based on actual dimensions of equipment furnished.

1.2 RELATED DOCUMENTS AND SECTIONS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

B. Division 06 sections for the construction of a custom audiovisual console for racks, cabling, wiring, devices, controls, adapters, etc. and other material and equipment required to complete the IPMS.

C. Division 26 sections for connections to fire-alarm systems, wiring, disconnect switches, and other electrical materials required to complete the IPMS.

D. Division 27 sections for communications racks, cabling, wiring, devices, adapters, etc. and other electrical materials required to complete IPMS.

1.3 GENERAL REQUIREMENTS
A. Guarantee: Furnish a written guarantee for a period of two years from date of acceptance.

B. All of the equipment in this specification shall be furnished and installed by the Authorized Factory Installer of the equipment with the most current software and firmware package available at the time of installation. At the time of Owner Acceptance of the installation, all equipment shall include any and all updated software or hardware revisions. In addition, when the software is available in disk format, a backup copy of the most up to date revision, in disk format, shall be handed to Owner at the completion of the project.

C. Verifying Drawings and Job Conditions:
   1. Examine all project drawings and specifications to ensure full awareness of all work required under this Section.
   2. Visit the site and verify existing conditions. Where existing conditions differ from drawings, make adjustments and allowances for all necessary equipment to complete all parts of the work. Verify actual dimensions of construction contiguous with Planetarium equipment by field measurements before fabrication.
   3. Pre-installation Conferences: Conduct a minimum of one conference at the project site prior to the start of installation work. Where existing conditions differ from drawings, make adjustment and allowances for all necessary equipment to complete all parts of the work.

1.4 WORK IN COOPERATION WITH OTHER TRADES
A. Examine the drawings and specifications and determine the work to be performed by the electrical and other trades. Provide the type and amount of audiovisual systems materials and equipment necessary to place this work in proper operation, completely wired, tested and ready for u

B. Confirm Low voltage conduit, boxes and power have been provided by the division 26 00 00 contractor.

1.5 TESTING AND ADJUSTMENT
A. Upon completion of all audiovisual systems work, provide testing and demonstrating in the presence of the owner's inspector that the all audio, digital video and control parameters are as stated in the factory data sheets.

B. Promptly repair or replace all equipment and parts discovered to be in need of correction. Then retest that part of the system and all associated components to correct the error. Perform all such replacement or repair at no additional cost to the Owner.

1.6 FINAL INSPECTION AND ACCEPTANCE

A. After all requirements of the specifications and/or the drawings have been fully completed, representatives of the Owner will inspect the work. Provide competent personnel to demonstrate the operation of any item or system to the full satisfaction of each representative.

B. Final acceptance of the work will be made by the Owner after receipt of approval and recommendation of acceptance from each representative.

1.7 RECORD DRAWINGS

A. Drawings of Record: Provide and keep up-to-date, a complete record set of drawings. Keep these corrected daily and show every change from the original drawings. Keep this set of prints on the job site for use only as a record set. This shall not be construed as authorization for your firm to make changes in the layout without Owner approval in each case.

B. Upon completion of the work, obtain a set of Contract Drawings from the General Contractor and create a record set professionally using a PDF editor. Deliver this set in PDF format as indicated in Submittals – Close-Out, below.

1.8 APPROVALS, EQUALS, SUBSTITUTIONS, ALTERNATIVES, NO KNOWN EQUAL

A. Approvals: Where the words (or similar terms) “approved”, “approval”, “acceptable”, and “acceptance” are used, these refer to the requirement that acceptance by the Owner, Architect and Engineer is required.

B. Equal: Where the words (or similar terms) “equal”, “approved equal”, “equal to”, “or equal by”, “or equal” and “equivalent” are used, it shall be understood that these words are followed by the expression “in the opinion of the Owner, Architect, and Engineer.” For the purposes of specifying products, the above words shall indicate the same size, made of the same construction materials, manufactured with equivalent life expectancy, having the same aesthetic appearance/style (includes craftsmanship, physical attributes, color and finish), and the same performance.

C. Substitution: For the purposes of specifying products “substitution” shall refer to the submittal of a product not explicitly approved by the construction documents/specifications.

1. Substitutions of specified equipment shall be submitted and received by the Engineer ten days prior to the bid date for review and written approval. Regulatory Agency approval for all substitutions will be the sole responsibility of the Contractor. To receive consideration, requests for substitutions must be accompanied by documentary proof of its equality with the specified material. Documentary proof shall be in letterform and identify the specified values/materials alongside proposed equal values/materials. In addition, catalog brochures and samples, if requested, must be included in the submittal.

ONLY PRE-BID APPROVED PRODUCTS, ISSUED VIA A FORMAL BID ADDENDUM TO ALL BIDDERS, WILL BE ALLOWED ON THE PROJECT. REGARDLESS OF THE APPROVAL ON ANY SUBSTITUTION, ALL BIDS SHALL BE BASED ON THE PRODUCTS
EXACTLY AS SPECIFIED. PRICING FOR EACH APPROVED SUBSTITUTION SHALL BE INCLUDED IN THE BID SUBMITTAL AS A SEPARATE LINE ITEM.

2. The Contractor warrants that substitutions proposed for specified items will fully perform the functions required.

D. Alternates/Alternatives: For the purposes of specifying products, “alternatives/alternates” may be established to enable the Owner/Architect/Engineer to compare costs where alternative materials or methods might be used. An alternate price shall be submitted in addition to the base bid for consideration. If the alternate is deemed acceptable, written authorization will be issued.

E. No Known Equal: For the purposes of specifying products, “No Known Equal” shall mean that the Owner/Architect/Engineer is not aware of an equivalent product. The Contractor will need to submit a “Substitution” item, per the requirements listed above, if a different product is proposed to be utilized.

1.9 SUBMITTALS – PRE-CONSTRUCTION

A. Submit the shop drawing submittal as PDF files accompanied by Letter of Transmittal, which shall give a list of the number and dates of the drawings submitted.

B. Provide consecutively numbered drawings featuring the name of the project that indicate the name of the specific staff that checked and approved each drawing. Any drawings submitted without this approval will be rejected.

C. If the shop drawings show variations from the requirements of the Contract because of standard shop practice or other reasons, make specific mention of such variations in the Contractor’s letter of transmittal. If the substitution is accepted, the Contractor shall be responsible for proper adjustment that may be caused by the substitution. Submit samples upon request.

D. Only products listed as “Equal” within the contract documents, along with formally approved “Substitutions” will be reviewed. Products not conforming to these items will be rejected.

E. Shop drawings shall be submitted on the following but not limited to:

   1. System functional diagrams, including control system wiring and audio DSP processing chain
   2. Equipment locations and methods for mounting
   3. Console layout, equipment placement, etc.
   4. All other products called out on drawings that call for shop drawing submittal

1.10 SUBMITTALS – CLOSE-OUT

A. Subsequent to completing preliminary testing, provide to the Construction Manager, Owner, and Planetarium consultant, a letter/report documenting the results of the preliminary tests and the documentation detailed below. The receipt of this documentation will constitute the acknowledgment that the installation is complete, that it conforms to this specification, and that it is ready to be reviewed and tested.

B. Operation and Maintenance Manuals: Provide all manuals as PDF files on three duplicate CD-ROM disks or USB drives, named consistently with the manufacturer’s name and the model number in separate folders for the planetarium and exhibit hall. Copy the same file and folder organization to the Owner.

   1. Provide step-by-step operating instructions for the day-to-day use of the system including power activation, connection of source devices, adjustment of volume levels, selection of sources, etc. Include illustrations and references to individual equipment manuals as nec-
2. Organize the manual PDF files into folders by subsystem: audio, video, control, etc.
3. Equipment List: Include an Excel or other spreadsheet file listing all equipment including connectors and specialty hardware. Include columns for manufacturer, model, physical location, MAC address, IP address, if fixed or DHCP, VLAN, serial number, and cable label identification.

C. As-built drawings: Provide all as-built documentation as PDF files on the disks and online service mentioned above. In addition, provide a single copy each of the functional drawings, floor plans, and ceiling plans as laminated full-size drawing sets.

PART 2 - SYSTEM EQUIPMENT SPECIFICATION

2.01 PLANETARIUM INSTRUCTIONAL AND EVENT PRESENTATION SYSTEM

A. This is provision and installation of a fully integrated instructional/classroom/event video/graphic system capable of projecting computer data graphics and text in addition to distance learning recording, streaming, and video conferencing. Please refer to drawings A.1 PL, AV1. BLOCK DRAWING, A1.CONSOLE, and TE1.PL. The selected contractor shall provide, install, train for, and support the following instructional media systems (IPMS):

1. INSET DOME PROJECTION SYSTEM. WUXGA projector produces a partial dome projection app. 8' high x 16' wide.

   Specified Model: Panasonic PT-EZ770 with mount attached to dome tension ring

2. ULTRA-SHORT THROW PROJECTION SYSTEM. This is an Ultra Short-Throw (0.23 ratio) Projector for roll-down screen. Native Resolution is 1920 x 1080.

   Specified Model: Viewsonic LS830 with wall mount PJ-WMK-304 Universal Wall Mount Kit

3. Two (2) 65" wall-mounted monitors

   Specified Model: Panasonic TH-65SF2U

4. Roll-down electric screen for 52" x 92" (16:9) image

   Specified Model: DA-LITE Tensioned Advantage Deluxe Electrol screen- DaMat surface -52" x 92"

5. 6 IN/4 OUT MEDIA MATRIX/ROUTING SWITCHER - for distributing six video/data sources with four outputs

   Specified Model: Crestron DM-MD6X4

   Please see attached cut sheets for above specified equipment

B. At the lab table location, the IPMS shall have connections vis to adjacent floor box location.
C. Video input and output from source devices to displays and projectors is achieved through routing of the matrix switcher.

D. System displays:
   1. Two data projectors one if front projecting on roll-down screen and one at the rear of the theater projecting on the dome screen (see 2.0.1 numbers #1 and #2)
   2. Two 65” wall mounted LED displays see (see 2.0.1 numbers #3)
   3. Fulldome Planetarium display located in center of theater and controlled at theater control console. Coordinate with Planetarium system provider.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION DESCRIPTION

A. Install Planetarium equipment level and plumb, according to manufacturer's written instructions and drawings from Planetarium Technology Consultant. The installation, configuration and wiring of the system shall be executed in accordance with the drawings and the equipment manufacturer's installation instructions and guidelines. Should any variations in these requirements occur, the Contractor shall notify the architect before making any changes. It shall be the responsibility of the factory-authorized installer of the approved equipment to install the equipment and guarantee the system to operate as per plans and specifications.

B. Complete equipment assembly and termination where field assembly is required.

D. Install equipment with access and maintenance clearances that comply with manufacturer's written installation instructions and with requirements of authorities having jurisdiction.

3.02 GENERAL TESTING REQUIREMENTS

A. Provide all instruments for testing and demonstrating in the presence of the owner's inspector that the all Audio, Digital Video and Control parameters are as stated in the factory data sheets. Check all circuits and wiring to verify they are free of shorts and grounds.

B. VOM shall be used to test continuity and phase of all new wiring and connections with the understanding that the system will function fully as designed.

C. Control functions shall be checked for proper operation, from controlling devices to controlled devices.

D. Adjust, balance, and align equipment for optimum quality and to meet the manufacturer's published specifications. Establish and mark normal settings for each level control with permanent machine printed labeling and provide in system documentation.

E. Controls: Adjust all controls to achieve the specified performance. Provide shaft-locks or covers for all level controls, as appropriate to prevent unauthorized gain changes. Confirm that all control system operations are properly programmed and repeatable.

F. Testing Report: Provide a letter/report documenting the results of these preliminary tests, including amplifier gain/level settings, crossover filter settings, and equalization curves for review by the AV Design Consultant.
G. Verify the following before beginning actual tests and adjustments on the System:

1. All electronic devices are properly grounded.
2. All powered devices have AC power from the proper circuit. All dedicated AC power circuits are properly wired, phased, and grounded.
3. Insulation and shrink tubing are present where required. All exposed bare wire shall be clear shrink wrapped or terminated within the phoenix block. NO exposed bare wire.
4. Dust, debris, solder splatter, etc. is removed.
5. All cable is dressed, routed, and labeled; all connections are properly made and consistent with regard to polarity.

H. Cable and Fiber.

1. Test all cables as installed for shorts between conductors or to building ground and for opens.
2. Certify all data cables installed to Category 6 standards or better.
3. Document all tests and complete measurement results including wire number, date, test equipment used, operator, and test results. If any problems are detected in testing, correct the problem, and retest.

I. Video System Tests:

1. Verify performance of all video connecting cables, as specified herein. Continuity tests are not acceptable. Replace any defective cable prior to continuing testing.
2. Perform video signal parameter tests on individual items of equipment, and the work as a whole in accordance with EIA, SMPTE and AES Recommended Practices and other recognized standards as listed under REFERENCES.
3. Provide full flat panel monitor display calibration and adjustments for optimal picture quality for a single HDMI input. Provide proper aspect ratio configuration for both 16:9 and 16:10 sources. Use a test generator for all setup verification, and verify proper image configuration with the all inputs. (Contract the Owner’s Technical Representative prior to final adjustment to coordinate).
4. Projection Systems:
   a. Luminance testing consistent with performance of specified projectors and screens.
   b. Brightness, convergence per ANSI standard procedures for device.
   c. Measure nine points of illuminance per screen and calculate average value in lumens.
   d. High-bandwidth Digital Content Protection (HDCP) check
5. At spaces with HDMI transmission:
   a. Run HDCP check to ensure all devices are HDCP compliant.
   b. Test with sample source device with quantity of HDCP keys as required to operate by the system.

3.03 ACCEPTANCE TESTS

A. Acceptance Test: Owner’s Representative and/or Construction Manager will be present during acceptance testing and require assistance. Provide personnel who participated in the actual installation and preliminary testing and adjustment of the audiovisual systems. At their option, the Owner may contract and pay for a third-party consultant to perform system testing. This cost is not included in the Contractor’s contract.

Demonstrate each major component to function as specified.
B. Such tests may be performed on any piece of the system or individual equipment/device. If any test shows the equipment or system is defective or does not comply with the specifications, perform any remedies at your firm’s expense and pay the subsequent expenses of any required retesting.

3.04 TRAINING AND FIELD SUPPORT

C. Training: System Functionality
   a. Provide a minimum of one, eight-hour day of prepared and organized training sessions (separate from full dome training sessions) for the benefit of the Owner’s personnel. Demonstrate the location, wiring, operation and capabilities of each system component. Training time is to be non-contiguous, in multiple separate sessions.
   b. Develop with CCC, a training schedule to allow for training. Training shall be of sufficient duration and depth and the schedule shall allow adequate time for personnel to absorb the training.
   c. At minimum, include training on each component of the IPMS.

3.05 MISCELLANEOUS PROJECT REQUIREMENTS

A. Single Point of Contact: Provide an English-proficient, single point of contact, i.e., project manager, to speak for the Contractor and to provide the following functions:
   1. Initiate and coordinate tasks with Owner’s Project Manager, and others as specified by Owner’s Project Manager.
   2. Provide day-to-day direction and on-site supervision of Contractor personnel.
   3. Ensure conformance with all Contract provisions.
   4. Participate in weekly site project meetings as needed.
   5. This individual will remain as Project Manager for the duration of the project. The Contractor may change Project Managers only with the Owner’s Project Manager’s written approval.

B. Planning meetings and schedule: Within thirty (30) calendar days after the date of award of the Contract, an initial planning meeting will be held with the successful bidder to clarify all requirements (systems, services, distribution methods, etc.), identify responsibilities, and schedule the events that will transpire during the implementation of the project. Within one week of this initial meeting, the Contractor shall provide a written report and project schedule to clearly document the events and responsibilities associated with the project.

C. Site Cleaning: Throughout the progress of the plant construction, the Contractor shall keep the working area free from debris of all types and remove from the premises all rubbish resulting from any work done by Contractor. On a daily basis and at the completion of its work, the Contractor shall, to the extent possible, leave the premises in a clean and finished condition.

D. Safety Requirements: Contractor will utilize appropriate personnel and display warning signs, signals, flags and/or barricades at the work site to ensure adherence to safety regulations and as prudence requires.

E. Specification/Drawing Status: All specifications and drawings related to this project will be “frozen” after shop drawing approval. The Owner reserves the right to negotiate any future changes with the Contractor at any time.

F. Upon approval of shop drawings, contractor shall immediately place orders for all required materials, components, and supplies. In addition, contractor shall secure and forward written confirmations (including orders and shipping dates) direct from each manufacturer/vendor to the Owner’s Project Manager.
G. Contractor shall expedite shipment of all materials, components and supplies, as necessary to ensure the successful completion of the Project by the date required. All costs for expediting shall be included within contractor’s pricing as provided below.

H. The system cost herein shall include administration/maintenance training for at least ten Owner’s representatives with a minimum allotment of sixteen (16) hours. All training shall include written and/or video materials that shall remain the property of Owner. If materials are written, they shall be provided in quantities sufficient for each person trained; if materials are video, one copy of each will be required. The administration/maintenance training shall include, but not be limited to, the following:
   1. Review of as-built documentation, including a site demonstration.
   2. All warranty information.

3.06 DAMAGES

A. The Contractor will be held responsible for any and all damages to portions of the building caused by it, its employees or sub-contractors; including but not limited to:
   1. Damage to any portion of the building caused by the movement of tools, materials or equipment.
   2. Damage to any component of the construction of spaces.
   3. Damage to the electrical distribution system.
   4. Damage to the electrical, mechanical and/or life safety or other systems caused by inappropriate operation or connections made by the Contractor or other actions of Contractor.
   5. Damage to the materials, tools and/or equipment of the Owner, its consultants, agents and tenants.
   6. Damage to the projection dome surface
   7. Damage, interference, or outage to campus wide area or local area networks.

3.07 INSPECTIONS

A. On-going inspections shall be performed during construction by the Owner’s Project Manager. All work shall be performed in a high quality manner and the overall appearance shall be clean, neat and orderly. The following points will be examined and must be satisfactorily complied with:
   1. Are all cables properly labeled, from end-to-end?
   2. Have all terminated cables been properly tested in accordance with the specifications for the specific category as well as tested for opens, shorts, polarity reversals, transposition and presence of AC and/or DC voltage?
   3. Have the pathway guidelines been followed? Are all cable penetrations installed properly and fire stopped according to code?
   4. Has the Contractor avoided excessive cable bending?
   5. Is Cable fill correct?
   6. Are terminations compatible with applications equipment?
   7. Are connectors properly turned right side up in the Jack Panels or faceplates without cables wrapped or twisted?
   8. Is the jacket maintained right up to the termination?
   9. Are identification markings uniform, permanent and readable?

3.08 COMPLETION OF WORK

A. At the completion of the System, restore to its former condition, all aspects of the project site. On a daily basis, remove all waste and excess materials, rubbish debris, tools and equipment
resulting from or used in the services provided under this Contract. Provide all clean up, restoration, and removal noted above at no cost to Owner. If the Contractor fails in its duties under this paragraph, the Owner may upon notice to the Contractor perform the necessary clean up and deduct the costs thereof from any amounts due or to become due to the Contractor. Remove trash from work areas and bring it to the Contractor-provided dumpster.

B. Final Punch Walk: Complete a final inspection to determine if all conditions of the scope of work are completed to the owner’s satisfaction. Provide a punch list within ten days of the punch walk and present it to the Contractor for completion prior to final project sign-off by the owner. If an item is missed during the punch walk or not included on the “punch list” for any reason, it does not release the Contractor from completing the scope of work as defined in the specification or drawings.

C. Contractor shall submit complete Record Documentation as outlined in submittals section prior to project sign-off by owner.

3.09 SYSTEM AND/OR NETWORK TESTING

A. Upon completion of installation, execute all of the tests listed in this specification. Provide the Owner, written notice when all such tests have been completed to Owner’s satisfaction and Manufacturer’s specifications, Contractor shall give the Owner written notice thereof.

B. Assume responsibility of assuring that the system and network interface installed operates properly, including any required coordination with other suppliers.

3.10 FINAL ACCEPTANCE

A. The Owner or Owner’s representative may visit the site during the installation of the system to ensure that correct installation practices are being followed.

B. Notify the Owner’s representative when the systems are ready for a final job review. The review will take place within one week after notification.

C. If need for additional adjustment becomes evident during final acceptance and/or demonstration and testing, continue adjustment until the system functions fully as designed.

D. The Owner or Owner’s representative will review the installation and certification data prior to the system acceptance.

E. The Owner or Owner's representative may test some of the system's features to ensure that the certification data is correct. If a substantial discrepancy is found, the Owner reserves the right to have an independent consultant perform a certification of the entire system. If such a procedure is undertaken, the cost of the testing will be billed back to the Contractor.

F. In the event that repairs or adjustments are necessary, make these repairs at your firm’s expense. Complete all repairs within five days from the time they are disclosed to your firm.
SECTION 272315 - PLANETARIUM SOUND SYSTEM (PSS)

PART 1 – GENERAL

1.1 PROJECT DESCRIPTION/WORK INCLUDED

A. The selected contractor shall provide, install, train for and support a Planetarium 5.1 Sound System with ADA Assistive Hearing (referred to as PSS) for the CCC Planetarium as shown in schematic and diagrammatic drawings A.1 PL, AV1. BLOCK DRAWING, A1.CONSOLE, TE1.PL., and TE1.SOUND.

B. The Planetarium takes the form of multi-use domed theater and, in addition to astronomy, is also used for general instruction/lecture and visualization by various College Departments including: Science, Engineering, and Math.

C. The design is based on the following components:

Audio Speakers:

SIX (6) JBL PRX612 Powered speakers attached to dome frame

TWO (2) JBL PRX618S (subwoofers)

Digital Processor: The TesiraFORTÉ AI or Dante Compatible Cinema processor

Rack Mounted Mixer: Ashly LX-308B Line Mixer

D. Unless otherwise noted, a substituted component may be proposed and included, but only if approved in advance by the Planetarium Design Consultant and/or the Contra Costa College.

E. This specification shall apply to all phases of Work hereinafter specified, shown on drawing, or as required to provide a complete installation. Work required under this specification, is not limited to just the 5.1 Sound System - refer to Architectural, Electrical, Structural, and Raceway/Structural Cabling, as well as all other drawing applicable to this project, which designate the scope of work to be accomplished. The intent of the drawings and Specifications is to provide a complete and operable planetarium system that includes all documents that are a part of the Contract.

1. Work Included. Furnish labor, material, services and skilled supervision necessary for the construction, erection, installation, connections, testing, and adjustment of all equipment specified herein, or shown or noted on drawings, and its delivery to the Owner complete in all respects ready for use.

2. The PSS work includes installation or connection of certain materials and equipment furnished by others. Verify installation details, installation and rough-in locations from the actual equipment or from the equipment shop drawings.

F. The associated system drawings are diagrammatic and are intended to convey the scope of work, indicating intended general arrangement of equipment. Follow drawings in laying out work and verify spaces for installation of materials and equipment based on actual dimensions of equipment furnished.
1.2 RELATED DOCUMENTS AND SECTIONS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

B. Division 06 sections for the construction of a custom audiovisual console for racks, cabling, wiring, devices, controls, adapters, etc. and other material and equipment required to complete the PSS.

C. Division 26 sections for connections to fire-alarm systems, wiring, disconnect switches, and other electrical materials required to complete the PSS.

D. Division 27 sections for communications racks, cabling, wiring, devices, adapters, etc. and other electrical materials required to complete PSS.

1.3 GENERAL REQUIREMENTS
A. Guarantee: Furnish a written guarantee for a period of two years from date of acceptance.

B. Wherever a discrepancy in quantity or size of conduit, wire, equipment, devices, circuit breakers, etc., (all materials), arises on the Drawing and/or Specifications, provide and install all material and services required by the strictest condition noted on drawings and/or in specifications to ensure complete and operable systems as required by the Engineer of record.

C. Documents that your firm is a factory-authorized installer and warrantee station for the brand of equipment offered and maintain a fully-equipped service organization capable of furnishing adequate repair service to the equipment. Maintain a spare set of all major parts for the system at all times. All circuit boards, amplifiers and control sub systems shall be 100% backed up with stock at your firm’s shop.

G. All of the equipment in this specification shall be furnished and installed by the Authorized Factory Installer of the equipment. Furnish a letter from the manufacturer of all major equipment, certifying that your firm is the Authorized Installer and that the equipment has been installed according to factory intended practices.

H. All of the equipment in this specification shall be furnished and installed by the Authorized Factory Installer of the equipment with the most current software and firmware package available at the time of installation. At the time of Owner Acceptance of the installation, all equipment shall include any and all updated software or hardware revisions. In addition, when the software is available in disk format, a backup copy of the most up to date revision, in disk format, shall be handed to Owner at the completion of the project.

I. Verifying Drawings and Job Conditions:
1. Examine all project drawings and specifications to ensure full awareness of all work required under this Section.
2. Visit the site and verify existing conditions. Where existing conditions differ from drawings, make adjustments and allowances for all necessary equipment to complete all parts of the work. Verify actual dimensions of construction contiguous with Planetarium equipment by field measurements before fabrication.
3. Pre-installation Conferences: Conduct a minimum of one conference at the project site prior to the start of installation work. Where existing conditions differ from drawings, make adjustment and allowances for all necessary equipment to complete all parts of the work.
1.4 WORK IN COOPERATION WITH OTHER TRADES
A. Examine the drawings and specifications and determine the work to be performed by the electrical and other trades. Provide the type and amount of audiovisual systems materials and equipment necessary to place this work in proper operation, completely wired, tested and ready for use.

B. Confirm Low voltage conduit, boxes and power have been provided by the division 26 00 00 contractor.

1.5 TESTING AND ADJUSTMENT
A. Upon completion of all audiovisual systems work, provide testing and demonstrating in the presence of the owner's inspector that the all audio, digital video and control parameters are as stated in the factory data sheets.

B. Promptly repair or replace all equipment and parts discovered to be in need of correction. Then retest that part of the system and all associated components to correct the error. Perform all such replacement or repair at no additional cost to the Owner.

1.6 FINAL INSPECTION AND ACCEPTANCE
A. After all requirements of the specifications and/or the drawings have been fully completed, representatives of the Owner will inspect the work. Provide competent personnel to demonstrate the operation of any item or system to the full satisfaction of each representative.

B. Final acceptance of the work will be made by the Owner after receipt of approval and recommendation of acceptance from each representative.

1.7 RECORD DRAWINGS
A. Drawings of Record: Provide and keep up-to-date, a complete record set of drawings. Keep these corrected daily and show every change from the original drawings. Keep this set of prints on the job site for use only as a record set. This shall not be construed as authorization for your firm to make changes in the layout without Owner approval in each case.

B. Upon completion of the work, obtain a set of Contract Drawings from the General Contractor and create a record set professionally using a PDF editor. Deliver this set in PDF format as indicated in Submittals – Close-Out, below.

1.8 APPROVALS, EQUALS, SUBSTITUTIONS, ALTERNATIVES, NO KNOW EQUAL
A. Approvals: Where the words (or similar terms) “approved”, “approval”, “acceptable”, and “acceptance” are used, these refer to the requirement that acceptance by the Owner, Architect and Engineer is required.

B. Equal: Where the words (or similar terms) “equal”, “approved equal”, “equal to”, “or equal by”, “or equal” and “equivalent” are used, it shall be understood that these words are followed by the expression “in the opinion of the Owner, Architect, and Engineer.” For the purposes of specifying products, the above words shall indicate the same size, made of the same construction materials, manufactured with equivalent life expectancy, having the same aesthetic appearance/style (includes craftsmanship, physical attributes, color and finish), and the same performance.

C. Substitution: For the purposes of specifying products “substitution” shall refer to the submittal of a product not explicitly approved by the construction documents/specifications.

1. Substitutions of specified equipment shall be submitted and received by the Engineer ten days prior to the bid date for review and written approval. Regulatory Agency approval for all
substitutions will be the sole responsibility of the Contractor. To receive consideration, requests for substitutions must be accompanied by documentary proof of its equality with the specified material. Documentary proof shall be in letterform and identify the specified values/materials alongside proposed equal values/materials. In addition, catalog brochures and samples, if requested, must be included in the submittal.

ONLY PRE-BID APPROVED PRODUCTS, ISSUED VIA A FORMAL BID ADDENDUM TO ALL BIDDERS, WILL BE ALLOWED ON THE PROJECT. REGARDLESS OF THE APPROVAL ON ANY SUBSTITUTION, ALL BIDS SHALL BE BASED ON THE PRODUCTS EXACTLY AS SPECIFIED. PRICING FOR EACH APPROVED SUBSTITUTION SHALL BE INCLUDED IN THE BID SUBMITTAL AS A SEPARATE LINE ITEM.

2. The Contractor warrants that substitutions proposed for specified items will fully perform the functions required.

D. Alternates/Alternatives: For the purposes of specifying products, “alternatives/alternates” may be established to enable the Owner/Architect/Engineer to compare costs where alternative materials or methods might be used. An alternate price shall be submitted in addition to the base bid for consideration. If the alternate is deemed acceptable, written authorization will be issued.

E. No Known Equal: For the purposes of specifying products, “No Known Equal” shall mean that the Owner/Architect/Engineer is not aware of an equivalent product. The Contractor will need to submit a “Substitution” item, per the requirements listed above, if a different product is proposed to be utilized.

1.9 SUBMITTALS – PRE-CONSTRUCTION

A. Submit the shop drawing submittal as PDF files accompanied by Letter of Transmittal, which shall give a list of the number and dates of the drawings submitted.

B. Provide consecutively numbered drawings featuring the name of the project that indicate the name of the specific staff that checked and approved each drawing. Any drawings submitted without this approval will be rejected.

C. If the shop drawings show variations from the requirements of the Contract because of standard shop practice or other reasons, make specific mention of such variations in the Contractor’s letter of transmittal. If the substitution is accepted, the Contractor shall be responsible for proper adjustment that may be caused by the substitution. Submit samples upon request.

D. Only products listed as “Equal” within the contract documents, along with formally approved “Substitutions” will be reviewed. Products not conforming to these items will be rejected.

E. Shop drawings shall be submitted on the following but not limited to:

1. System functional diagrams, including control system wiring and audio DSP processing chain
2. Speaker locations and mounting details.
3. Single Line schematic drawings showing connections between all audio components.
4. All other products called out on drawings that call for shop drawing submittal

1.10 SUBMITTALS – CLOSE-OUT

A. Subsequent to completing preliminary testing, provide to the Construction Manager, Owner, and Planetarium consultant, a letter/report documenting the results of the preliminary tests and the documentation detailed below. The receipt of this documentation will constitute the
acknowledgment that the installation is complete, that it conforms to this specification, and that it is ready to be reviewed and tested.

B. Operation and Maintenance Manuals: Provide all manuals as PDF files on three duplicate CD-ROM disks or USB drives, named consistently with the manufacturer’s name and the model number in separate folders for the planetarium and exhibit hall. Copy the same file and folder organization to the Owner.
   1. Provide step-by-step operating instructions for the day-to-day use of the system including power activation, connection of source devices, adjustment of volume levels, selection of sources, etc. Include illustrations and references to individual equipment manuals as necessary. Hyperlink the references to the individual operation manual files included in this submission.
   2. Organize the manual PDF files into folders by subsystem: audio, mixer control, etc.
   3. Equipment List: Include an Excel or other spreadsheet file listing all equipment including connectors and specialty hardware. Include columns for manufacturer, model, physical location, speaker cable assignment, and sound source cable label identification.

C. As-built drawings: Provide all as-built documentation as PDF files on the disks and online service mentioned above. In addition, provide a single copy each of the functional drawings, floor plans, and ceiling plans as laminated full-size drawing sets.

PART 2 - PLANETARIUM SOUND SYSTEM (PSS)

2.01 5.1 AUDIO SYSTEM

Objective: To provide a spatial sound system with programmable configurations that supports programming inclusive of stereo, AND 5.1 surround, spatial sound formats and dedicated voice channel assignment for in-room reinforcement over a digital audio network.

A. The sound system should provide a minimum of 6 channels (5.1) of digital audio through a DSP/Dante Compatible Sound Processor.

B. Per drawing TE1.SOUND, the five (5) upper speakers attached to dome frame shall be Powered, 1000W, 12” two-way, bass-reflex system with 90° x 50° nominal coverage pattern. Specified Model: JBL PRX 612. Per drawing TE1.SOUND two (2) subwoofers mounted above entrance vestibule in adjacent wall.

The combined speaker systems shall provide a combined 100 dB ±3dB continuous sound level for nominal maximum loudness (measured with pink noise at the center of the theater 3-0’ AFF), from 100Hz-12KHz and a sound pressure level minimum of 100 dB ±10dB from 41Hz to 18KHz.

C. PSS will have a dedicated Public Address (PA) Single Speaker system for live presentations and announcements, that is included in the PSS design.

D. PSS audio sources include (A-Chain), but are not limited to the following:

1. Fulldome Planetarium Projection System (FPPS) – stereo and 5.1 channel source. PSS provider is to coordinate audio/video playback with FPPS provider.

2. One dual-receiver UHF wireless microphone system with headset, handheld and lavaliere element. Dual channel receiver for this feature to be located in the planetarium Console or attached to the planetarium dome screen tension ring. Specified Models: No substitution to meet Owner standards.
a. One Shure ULXD4D dual receiver with:
b. One ULXD2/SM58 handheld transmitter.
c. One ULXD1 body pack transmitter.
d. One WCM16 headset mic.
e. One WL184 lavalier mic.
f. Required frequency G50 band: 470-574 MHz.

3. One analog mixing system. The mixer shall be installed in the Planetarium Control Console Rack:
   Specified Model: Ashly LX-308B Line Mixer

4. DSP digital processor (Dante Compatible) will provide channel routing, equalization, limiting, frequency crossovers and all other processing. Installed in the Planetarium Control Console Rack:
   Specified Model: The TesiraFORTÉ AI or USL JSD-100

E. Eight (8) Speaker System (B-Chain).
   a. 6 (six) two-way self-powered speakers with 12 inch LF driver and 1.5" HF drivers with maximum dispersion of 90° x 50° attached to projection dome as shown in drawing TE1.SOUND. Maximum weight unmounted: 40 pounds. Mounts are to be either obtained by the Dome Manufacturer or approved by the Dome Manufacturer with written confirmation that mounts, if properly installed, do not nullify the dome manufacturer’s warranty. The Electrical Power for these speakers are to switched on/off at the wall behind the Control Console. Vendor is coordinate with the electrical contractor.
   Specified Model: JBL PRX 612M

   b. 2 (two) self-powered subwoofer speakers mounted and secured to the top level above the light lock/foyer as shown in drawing TE1.SOUND.
   Specified Model: JBL PRX 618S

2.02 ASSISTIVE LISTENING SYSTEM

A. System must meet current California ADA specifications. 2010 ADA compliance specs are used here as reference.
   Specified Model: See below.
   1. Listen Technologies LT-800-072-01 Transmitter with rack mount kit. Mount this feature in audio rack in Operator's Console.
   2. Listen Tech LR-4200-072-P1. Intelligent DSP RF Receiver Package
   3. Five Intelligent DSP RF Receivers (72 MHz).
   4. Five LA-430 Intelligent Ear Phone/Neck Loop Lanyard.
   5. Five LA-401 Intelligent Ear Speaker.
   6. Five LA-365 Rechargeable Li-ion Battery
7. One LA-381-01 Intelligent 12-Unit Charging Tray  
    One LA-304 Assistive Listening Notification Signage Kit.

2.03 TRAINING AND FIELD SUPPORT

Training: System Functionality
   a. Provide a minimum of one, eight-hour day of prepared and organized training sessions (separate from full dome training sessions) for the benefit of the Owner’s personnel. Demonstrate the location, wiring, operation and capabilities of each system component. Training time is to be non-contiguous, in multiple separate sessions.
   b. Develop with CCC, a training schedule to allow for training. Training shall be of sufficient duration and depth and the schedule shall allow adequate time for personnel to absorb the training.
   c. At minimum, include training on each component of the PSS.

END OF SECTION
SECTION 27 41 13 ARCHITECTURALLY INTEGRATED PROJECTION SCREENS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:
   1. Roll-up, electrically operated projection screens

B. Related Sections:
   1. Section 055000 - Metal Fabrications: Metal fasteners and other support components for suspending projection screens.
   2. Section 061000 - Rough Carpentry: Wood blocking for installation of projection screens.
   3. Section 092900 - Gypsum Board Assemblies: Suspended gypsum board ceilings to contain recessed projection screens.
   4. Section 095100 - Acoustical Ceilings: Suspended acoustical panel ceilings to adjoin recessed projection screens.
   5. Division 26: Electrical supply, conduit, and wiring for motorized projection screens.

1.2 SUBMITTALS

A. See section 270000 for submittal requirements
B. Bidder is responsible for coordination with all affected trades for the integration of substituted products.

1.3 QUALITY ASSURANCE

A. Source limitation: Obtain projection screens from a single manufacturer as a complete unit including necessary mounting hardware, motor, controls, limit switches, and accessories.
B. Motorized projection screens shall bear UL label and be certified for use in the United States by Underwriters Laboratory (UL), Inc.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver projection screens when building is enclosed, other construction within spaces where screens will be installed is substantially complete, and installation of screens is ready to begin.
B. Deliver products in manufacturer's original, unopened, undamaged containers with labels intact.
PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Da-Lite Screen Company, 3100 North Detroit Street, Post Office Box 137 Warsaw, IN 46581-0137, (800) 622-3737

B. Manufacturers of equivalent products submitted and approved in accordance with Section 01630 - Product Substitution Procedures.

2.2 MOTORIZED PROJECTION SCREENS

A. Motorized Projection Screen Schedule

<table>
<thead>
<tr>
<th>Room</th>
<th>Viewing Area (H x W)</th>
<th>Comments</th>
<th>Enclosure (H x W x D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>72 OCC Classroom</td>
<td>65&quot; x 104&quot;</td>
<td>Matte white material. Supply screen with additional black drop at top as necessary to ensure bottom of image is no higher than 48&quot; AFF, UON.</td>
<td>6.38&quot; x 115.75&quot; x 7.75&quot;</td>
</tr>
</tbody>
</table>

B. Type: Recessed, plenum-rated, electrically-operated, retractable projection screen with rigid metal roller housing screen motor and screen tensioning system; Tensioned Advantage Electrol as manufactured by Da-Lite Screen Company, Inc. or approved equivalent from another authorized vendor.

C. Unless otherwise noted, provide a low-voltage interface integrated within the projection screen enclosure.
   1. Low-voltage interface shall provide connection points for Contractor-installed field wiring.

D. Method of installation: Recessed in ceiling.

E. Screen case: Extruded aluminum with steel end brackets designed to receive mounting hardware.
   1. Ceiling flange: Case is to be provided with a bottom flange to accommodate adjacent ceiling finish.
   2. Case access door: A door shall be provided at the bottom of the case to permit access to the roller.
   3. Finish: White, powder coating unless otherwise noted.

F. Tensioning system: Tab guide cable system shall be provided to maintain even lateral tension and to hold viewing surface flat.

G. Integral junction box: Projection screen housing shall contain connector for connection to motorized roller/viewing surface assembly. Housing can be installed and wired to electrical supply during construction. Motorized roller assembly shall be installed later after construction is substantially complete.

H. The screen fabric shall be permanently attached to the roller. The bottom of the screen shall be weighted.

I. MOTOR
   1. Type: 110-120 VAC, 60 HZ, 3-wire, instantly reversible, lifetime lubricated, and equipped with internal thermal overload protector, electric brake, and pre-set accessible limit switches
2. Integrated in-screen roller on vibration insulators

J. CONTROLS

1. Low voltage control: Unless otherwise noted, provide single-gang Decora-type control with pushbuttons or membrane switches for up, down and stop functions and with an electrical interface providing contact closure connections for interface with projection screens and remote control systems.

2. In rooms with two screens, label the switch operating the screen to the class’s left, “LEFT” and the switch for the right screen, “RIGHT.”

2.3 MANUALLY-OPERATED PROJECTION SCREENS

A. Manually-Operated Projection Screen Schedule

<table>
<thead>
<tr>
<th>Room</th>
<th>Viewing Area (H x W)</th>
<th>Comments</th>
<th>Enclosure (H x W x D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom/Lab Type A</td>
<td>57.5” x 92”</td>
<td>Matte white material. Supply screen with</td>
<td>5.88” x 99.25” x 4.63”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>additional black drop at top as necessary to</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ensure bottom of image is no higher than</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>48” AFF, UON. Supply pull rod for</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Classroom/Lab Type B rooms.</td>
<td></td>
</tr>
<tr>
<td>Classroom/Lab Type B</td>
<td>65” x 104”</td>
<td></td>
<td>5.88” x 111.25” x 4.63”</td>
</tr>
</tbody>
</table>

1. Classroom/Lab Type A:
   a. 40 OCC Classroom
   b. 36 OCC Classrooms (111, 112, and 113)
   c. Anatomy Lab
   d. Physio Lab
   e. Microbio Lab
   f. Gen Bio Lab
   g. O-Chem Lab
   h. General Chemistry Lab
   i. Biotech Lab
   j. Intro Chem Lab

2. Classroom/Lab Type B:
   a. 50 OCC Classroom
   b. Computer Lab

B. Type: Manually operated, retractable projection screen with rigid steel spring roller; Model C with CSR Projection Screen as manufactured by Da-Lite Screen Company, Inc. or equivalent from another authorized vendor

C. Method of Installation: Wall Mounted using 6-inch wall brackets. Ensure that the screen clears whiteboards and does not swing when retracting.

D. Screen Case
   1. Flat-backed steel case with end caps concealing roller ends.
   2. Case Finish: powder coated white.
      a. Include a powder-coated weight at bottom of screen with pull bail.
2.4 VIEWING SURFACE

A. Material: Flame retardant, mildew resistant, smooth, white fabric that can be rolled and can be cleaned with a mild soap and water solution. Da-Mat if a Da-Lite screen, otherwise the specified manufacturer’s equivalent.

B. Joints: Viewing surface shall contain no seams.

C. Provide with black masking borders.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of projection screens with ceiling construction and related components penetrating or above ceilings such as lighting fixtures, mechanical equipment, ductwork, and fire-suppression system.

B. Coordinate requirements for blocking, structural supports, and bracing to ensure adequate means for installation of screens.

C. Coordinate requirements for power supply conduit, and wiring required for projection screen motors and controls.

D. Coordinate installation of recessed mounted screens with construction of suspended acoustical panel where appropriate. Where acoustical ceiling panels are to be adhered to screen case closure, provide and coordinate required tolerances and weight restrictions.

E. Prior to installation, verify type and location of power supply.

3.2 INSTALLATION

A. Install projection screens and controls at locations and heights indicated on Drawings.

B. Comply with screen manufacturer's written instructions and shop drawings.

C. Install screen housing and make electrical connections prior to installation of suspended ceiling system. After interior construction is essentially complete, install viewing surface and drive assembly in housing.

D. Install screens securely to supporting substrate so that screens are level and back of case is plumb and does not swing during operation.

E. Provide required brackets, hanger rods, and fasteners.

F. Adjust limit switches to position bottom of projection screen image areas at 48” AFF or as otherwise noted.

G. Adjust tensioning lines to eliminate ripples and other non-flat areas of fabric.

H. Install projector screens so that the screen is not obstructed as it raises or lowers by any object mounted beneath it on the same wall.

3.3 TESTING AND DEMONSTRATION

A. Test motorized projection screens to verify that screen, controls, limit switches, closure, and other operating components are functional. Ensure that screen is level and viewing surface plumb when extended. Correct deficiencies.

B. Demonstrate operation of screen to Owner's designated representatives.

3.4 PROTECTING
A. Protect projection screens after installation from damage from construction operations. If damage occurs, remove and replace damaged components or entire unit as required to provide units in their original, undamaged condition.

END OF SECTION
SECTION 27 41 16 INTEGRATED AUDIOVISUAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes: Audiovisual systems – presentation systems, control systems, and interface with other systems. Refer to 1.04 System Description for more information.

B. Base bid work

1. Provide equipment and materials, whether specifically mentioned herein or not, needed for a complete and operating audiovisual systems to satisfy the requirements of this section and related drawings. This specification lists major equipment but not every wire, connector, extender, converter, fastener, etc., needed to complete the work.

2. Equipment racks:
   a. Floor-standing racks: Provide floor-standing equipment racks as shown on the drawings, including frame, side panels, top panels, and front and back doors, anchorage and seismic bracing as required.
   b. Provide standard or custom rack shelves and mount adapters for equipment installed in equipment racks as needed to properly mount equipment, power supplies, accessories, components, and the like. Provide cable management to properly route and mind wires, cables, and cords.
   c. Provide power receptacle strips in quantities needed to supply power to the equipment within the rack.
   d. Within racks greater than 18 RUs, provide one work light in the front and one in the back of each rack.
   e. Provide spare rack mounting screws. Determine based on rack mount units (RUs) – one spare screw per two RU installed, minimum.
   f. Provide bonding for racks, cabinets, equipment, equipment support and cable/wire management to an approved grounding point.

3. Cooling provisions
   a. Provide cooling provisions (means to move heat out of enclosed spaces to prevent temperatures from exceeding equipment manufacturers' specified maximums). Ensure equipment operates within manufacturer’s cooling guidelines. Provide only code-compliant cooling provisions (e.g., exhausting from one space to another).
   b. In racks, enclosures, millwork, cabinets, and other spaces where equipment will be installed and prone to heat buildup, provide thermostatically-controlled active cooling devices to create adequate airflow through the enclosed space. Examples of active cooling devices include vent fans. At a minimum, ensure airflow by installing active cooling devices or systems such as fans.

4. Labeling: Provide labeling for audiovisual system components. The components include, but are not limited to, the following:
   a. Equipment racks and equipment enclosures
   b. Rack-mounted equipment and devices: Provide a label on the back of each piece of equipment. If a serial number (of a given piece of equipment) is not visible in a final installed condition, provide a label on the equipment on a visible location duplicating the serial number.
   c. Wall-mounted equipment and devices: Provide an equipment label on the back of each piece of equipment. If a serial number (of a given piece of equipment) is not visible in a final installed condition, provide a label on the equipment on a visible location duplicating the serial number.
d. Provide an equipment plate for each piece of equipment.

e. Provide a label for each control that is not inherently labeled, such as those in racks and user spaces.

e. Wires and cables: Provide a cable label at each end of each piece of wire, cable and cord.

g. Handheld, lavalier, wireless, and other microphones and associated equipment (such as receivers)

h. User interface devices/plates

5. Coordination requirements

a. Coordinate with the construction team at large to ensure that equipment and other system components will be installed properly, and that there will be no compromises due to, among other aspects, spatial conflicts or power service incompatibilities.

b. Coordinate with the electrical contractor for power requirements and service connection to the System’s equipment.

c. Coordinate with the telecom contractor and other trades/contractors (as needed) placement of cables and wires when sharing pathways (such as cable tray) with other low voltage systems. Do not place cables and wires into pathways provided by others without permission.

d. Coordinate with the Owner for network configurations and/or settings required for the System’s proper or correct operation.

C. Related divisions and sections: Consult other divisions, determine the extent and character of related work. Coordinate the work of this section with, at least but not limited to, the following divisions and sections:

1. Division 0 (for Bidding Requirements, Contract Forms, and Conditions of Contract) and Division 1 (for General Requirements) – provisions listed or specified therein apply to work under this section.

2. Section 270000, “Communications Basic Requirements”
4. Section 062000, “Finish Carpentry”
5. Division 26, “Electrical Systems”
7. Section 271513, “Communications Horizontal Cabling”
8. Section 270811, “Communications Twisted Pair Testing”

D. Products installed but not furnished under this section

1. Owner-furnished, contractor-installed (OFCI) equipment
E. Products furnished and installed under another sections
1. Rough-in (device boxes, conduits, and related accessories)
2. Electrical service (e.g., 120 VAC); refer to division 26
3. Telecommunication cabling; refer to Section 271513
4. Telecommunication pathways; refer to Section 270528 and/or 270532.

F. Room types
1. The audiovisual systems design and documentation are based on standard room types.
2. Each room to receive audiovisual systems is shown on the drawings with a type designation.
3. Refer to the drawings for the quantities of each type of room and for specific audiovisual interface information per room.
4. 72 OCC (occupant) Classroom
5. Biotech Lab
6. Meeting Room
7. General Classroom
   a. 50 OCC Classroom
   b. 40 OCC Classroom
   c. 36 OCC Classroom (Room 111, 112, and 113)
8. General Lab
   a. Anatomy Lab
   b. Physio Lab
   c. Microbio Lab
   d. Computer Lab
   e. Gen Bio Lab
   f. O-Chem Lab
   g. General Chemistry Lab
   h. Intro Chem Lab
   i. Engineering Lab
   j. Physics Lab

1.2 REFERENCES

A. Comply with the References requirements of Section 270000.
B. In additional to the references listed in Section 270000, perform work in accordance with applicable requirements of governing codes, rules and regulations including the following minimum standards, whether statutory or not:
1. National Fire Protection Agency (NFPA)
   a. NFPA 262, “Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces”
2. Underwriters Laboratories (UL)
   a. UL 969, “Marking and Labeling Systems”
   b. UL 1419, "Professional Video and Audio Equipment"
   c. UL 60065, “Audio, Video and Similar Electronic Apparatus – Safety Requirements”
3. InfoComm
   a. InfoComm 1M, “Audio Coverage Uniformity in Enclosed Listener Areas”
   c. InfoComm 3M, “Projected Image System Contrast Ratio”
   d. InfoComm F501 01, “Cable Labeling for Audiovisual Systems”

4. “Sound Systems Engineering”, 3rd Ed., Davis and Davis

5. Electronic Components Industry Association (ECIA)
   a. EIA/ECA-310, “Cabinets, Racks, Panels, and Associated Equipment”

1.3 DEFINITIONS

A. The definitions in Section 270000 apply to this section.
B. In addition to those definitions in Section 270000 and Division 01, the following terms used in this specification are defined as follows:

1. “ACEG”: alternating current equipment ground (an example of this is a ground bus within an electrical panel)
2. “Approved Grounding Point”: an approved grounding point is one that satisfies the applicable electrical code and provides a low impedance path to earth. Examples include the following though may manifest in different means: a telecommunications grounding busbar (such as for bonding an equipment rack within a telecom room), the ACEG of the electrical panel serving the equipment requiring bonding to ground (such as for bonding a credenza rack within a conference room), or the ground conductor of a branch circuit (such as for bonding a single piece of equipment).
3. “A/R”: Indicates that the quantity of an item is as required to meet the design criteria indicated in the audiovisual drawings and specifications.
4. “A/S”: Indicates that the quantity of an item is as shown on the drawings.
5. “Audience Area”: the portion of a presentation space intended to be occupied by an audience. An audience area includes the primary seating and standing spaces and may include the adjacent circulation spaces. An audience area generally excludes spaces reserved for presenters.
6. “Custom” indicates systems or components the Contractor fabricates based on these specifications and drawings
7. “EDID”: Extended display identification data
8. “HDCP”: High-bandwidth digital content protection
9. “HDMI”: High-definition multimedia interface
10. “OFE”: Owner-furnished Equipment
11. “Or equal” indicates an item that is equal in function and performance to the specified device or system
12. “RU”: rack unit, as defined in EIA/ECA-310
13. “Shall” denotes a mandatory requirement
14. “Should” denotes an advisory statement
15. “SPL”: sound pressure level
16. “THD”: total harmonic distortion
17. “Will” denotes an informative statement
18. “Project”: The scope of work defined by this specification and its related drawings
19. “Software”: Any executable programs, parameter files, user interfaces, or other coded content that are required to operate, control, or maintain the audiovisual systems in this Project
20. “Custom Created Software”: Any software, parameter files, user interfaces, or other coded content created for the control or operation of the audiovisual systems in this Project.

21. “Third-party software:” Any programming developed by a party other than the AV Contractor and the Owner to be used to operate, control, or maintain the audiovisual systems in this Project.

22. “System”: The audiovisual components, cabling, and programming incorporated in the descriptions and equipment lists herein.

1.4 SYSTEM DESCRIPTION AND PERFORMANCE REQUIREMENTS

A. General

1. In circumstances where the specifications and drawings conflict, the drawings govern quantity and the specifications govern quality.

2. The contract drawings and specifications convey design intent. They are not intended to be used in lieu of shop drawings.

B. ADA compliance: Provide the following:

1. Accessible control systems

2. Assistive listening systems

C. Audio system

1. Provide echo cancellation for microphones in audio and video conferencing systems.

2. Program audio system:
   a. Frequency Response: 100 Hz to 12,000 Hz. 3 dB per octave roll off below 100Hz and above 12 kHz.
   b. Total Acoustical Harmonic Distortion: Less than 2% at 90 dBC (1 kHz reference) at four feet (1,220 mm) above finished floor in the middle of the room.

3. Distributed audio system:
   a. Frequency Response: 125 Hz to 10,000 Hz. 3 dB per octave roll-off below 125 Hz and above 10 kHz.
   b. Total Acoustical Harmonic Distortion: Less than 2% at 85 dBC (1 kHz reference) at four feet (1,220 mm) above finished floor in the middle of the room.

4. Signal to noise ratio (mixer input to amplifier output): 75 dB from 50 Hz to 15 kHz minimum.

5. Frequency response with equalizers bypassed: less than ±1 dB from 50 Hz to 12 kHz.

6. Distortion: less than 0.5% at 1 kHz at the equipment's rated input signal level.

7. Output levels (in audience areas without objectionable distortion, rattles, or buzzes, employing as test signals several different samples of recorded music and microphones applied at each system input):
   a. Program audio: not less than 95 dB
   b. Speech reinforcement: not less than 85 dB

8. Hum and Noise: inaudible (below the background noise level of the space) under normal operation observed in audience areas.

D. Video system resolutions

1. Provide system components with a minimum resolution capability of 1920 X 1080.

2. Provide systems that support the following resolutions: 1,280 x 720, 1,920 x 1,080, 1,920 x 1,220, 3840 X 2160, and 4096 x 2160.
E. Direct-view display systems
   1. Provide displays that have no more than seven defective pixels per quadrant, or per manufacturer’s spec. Reject any display with a greater number of defective pixels.

F. Wireless systems
   1. Ensure that wireless AV systems do not create radio frequency interference to other systems.
   2. Demonstrate at AV acceptance testing that wireless AV systems are not adversely affected by AV-related or other radio frequency sources.

G. Control system
   1. Provide user interfaces, such as control panels, that respect ergonomics and varying levels of technical ability among users. Follow these guidelines:
      a. Avoid abbreviations
      b. Size lettering at 1/8” minimum
      c. Maintain background to lettering contrast
   2. Positive logic: Avoid conditions which may cause command synchronization conflicts (i.e., alternate action (toggling) on/off without power reset or feedback. Provide power sensors or other devices where necessary to ensure that positive logic conditions are maintained.
   3. Timing: Prevent two or more commands being sent simultaneously to the same piece of equipment.
   4. Linking: Provide linking of functions to require the fewest number of user actions to effectively control the equipment.
   5. Clearing: Ensure that each media selection clears the previous audio and visual selection (e.g., selecting COMPUTER clears the audio and video section of the previous Blu-ray disk selection).
   6. Defaults: Establish default power-up conditions for the system including device audio levels, warm-up routine, power conditions, switcher status and other default conditions as required by the Owner or Owner’s representative.
   7. Volume Memory: Provide easy-to-use memory for volume settings associated with each source device. Unless directed otherwise in this document, provide programming that maintains these settings between alternate selections during each use – through power-on and power-off.
   8. Status indication: Program buttons for both touch panels and pushbutton panels to provide clear status indication using illumination when back-lighting is available or by changing color.
   9. Failsafe: Provide program that ensures that no operation or sequence of operations causes the control system to become inoperable or interferes with further processing, correct operations or execution of commands.

1.5 ROOM TYPES

A. 72 OCC Classroom
   1. General
      a. This room type will provide a large instructional space designed for lecture-style presentations.
b. The projectors will display content selected by the user via the push-button controller.
c. The confidence monitors will duplicate any displayed source selected by the user.
d. A local confidence monitor will be located at the instructor desk.
e. Provide camera presets on control panels. Coordinate with the Owner to determine and program these presets.

2. Audio System
   a. Provide ceiling loudspeakers for program audio. Ceiling loudspeakers in the back of the classroom will be used for program audio and voice amplification.
   b. Provide ceiling-mounted microphones for instructor voice pick-up.
   c. Provide a wireless lavalier system for instructor voice pick-up.
   d. Provide an audio digital signal processor.
   e. Provide an audio amplifier with a security cover to prevent tampering.
   f. Provide an assistive listening system to meet ADA requirements.

3. Video System
   a. Provide a ceiling-mounted video projector on a fixed mounting pole.
   b. Provide projector mounts and poles.
   c. Provide a wall-mounted display and associated mount that will serve as a confidence monitor.
   d. Provide a display at the instructor’s desk that will serve as a confidence monitor.
   e. Provide a video switcher.
   f. Provide an HDMI distribution amplifier.
   g. Provide an HDBaseT distribution amplifier.
   h. Provide scaling HDBT transmitters and receivers.
   i. Provide wall-mounted PTZ cameras and associated mounts.
   j. Provide an HDMI switch to select the PTZ camera that is being sent to the lecture capture device.
   k. Provide a camera HDBaseT receiver.
   l. Provide a networked lecture capture device. Coordinate with the Owner on lecture capture device user interface.
   m. Provide a Blu-ray player in the equipment rack.
   n. Provide a document camera at the instructor position.
   o. Provide 12-foot cables with HDMI, VGA, USB, and 3.5mm audio connectors at the lectern.
   p. Provide a composite video input, including stereo audio, with user-accessible cabling, coiled neatly inside the equipment rack to support an Owner-furnished VHS player.
   q. Install an Owner-furnished PC in the equipment rack.

4. Control System
   a. Provide a lectern mounted, hard button remote control for system control.
   b. Provide a networked room controller.
   c. Controls should include but are not limited to audio volume up/down and mute, input source selections, PTZ camera presets, standard BluRay device controls and the ability to navigate media device menus.
5. Miscellaneous
   a. Provide a technology lectern with an integrated equipment rack for the audiovisual system headend.

B. Biotech Lab
   1. General
      a. Instructional space designed for lab-style presentations and interactive presentation of content throughout the space.
      b. The projector will display content as selected by the user via the push-button controller.
      c. Wall-mounted HDMI connections in the classroom will allow users to present content.
      d. A local confidence monitor will be located at the instructor desk.
      e. Provide camera presets on control panels. Coordinate with the Owner to determine and program these presets.

   2. Audio System
      a. Provide ceiling loudspeakers for program audio.
      b. Provide ceiling-mounted microphones for instructor voice pick-up.
      c. Provide a wireless lavalier system for instructor voice pick-up. Both the ceiling-mounted microphone and wireless lavalier system will be fed into the assistive listening system and lecture capture system but not through the ceiling loudspeakers.
      d. Provide a digital signal processor.
      e. Provide an audio amplifier with a security cover to prevent tampering.
      f. Provide an assistive listening system to meet ADA requirements.

   3. Video System
      a. Provide a ceiling-mounted video projector on a fixed mounting pole.
      b. Provide projector mount.
      c. Provide a display at the instructor’s desk that will serve as a confidence monitor.
      d. Provide video switcher.
      e. Provide an HDMI distribution amplifier
      f. Provide an HDMI switcher.
      g. Provide VGA to HDMI converters for the classroom computers.
      h. Provide a scaling HDBT transmitters and receivers.
      i. Provide wall-mounted PTZ cameras and associated mounts.
      j. Provide an HDMI switch to select the PTZ camera that is being sent to the lecture capture device.
      k. Provide a camera HDBaseT receiver.
      l. Provide a networked lecture capture device. Coordinate with Owner on lecture capture device user-interface.
      m. Provide a Blu-ray player in the equipment rack.
      n. Provide a document camera at the instructor position.
      o. Provide wall-mounted HDMI connections.
      p. Provide 12 ft HDMI, VGA, and 3.5mm audio connectors at the lectern.
      q. Provide a composite video input, including stereo audio, with user-accessible cabling, coiled neatly inside the equipment rack to support an Owner-furnished VHS player.
      r. Install an Owner-furnished PC in the equipment rack.
4. Control System
   a. Provide a lectern mounted, hard button remote control for system control.
   b. Provide a networked room controller.
   c. Controls should include but are not limited to audio volume up/down and mute, input source selections, PTZ camera presets, standard BluRay controls and the ability to navigate media device menus.

5. Miscellaneous
   a. Provide an equipment rack.

C. Meeting Room
1. General
   a. Space intended for scheduled and impromptu meetings, trainings, and presentations.

2. Audio System
   a. Program audio will be provided by the display.

3. Video System
   a. Provide a wall-mounted display and associated mount.
   b. Provide a video switcher.
   c. Provide scaling HDBaseT receivers.
   d. Provide an HDBaseT auto-switch. Provide 12ft VGA with audio, USB, and two HDMI cables at the table for laptop input.
   e. Provide a conferencing soundbar with camera.
   f. Provide a Blu-ray player in the equipment rack.
   g. Install an Owner-furnished PC in the equipment rack.

4. Control System
   a. Provide a wall-mounted pushbutton control panel for system control.
   b. Provide a networked room controller.
   c. Controls should include but are not limited to audio volume up/down and mute, input source selections, standard BluRay controls and the ability to navigate media device menus.

5. Miscellaneous
   a. Provide USB transmitter and receiver.
   b. Provide a credenza equipment rack.

D. General Classroom
1. General
   a. This room type applies to the following rooms: 50 OCC Classroom, 40 OCC Classroom, and 36 OCC Classroom (Room 111, 112, and 113).
   b. Instructional space designed for lecture-style presentations.
   c. The projector will display content as selected by the user via the push-button controller.
   d. The confidence monitors will duplicate any displayed source as selected by the user.
   e. A local confidence monitor will be located at the instructor desk.
   f. Provide camera presets on control panels. Coordinate with the Owner to determine and program these presets.
2. Audio System
   a. Provide ceiling loudspeakers for program audio.
   b. Provide ceiling-mounted microphones for instructor voice pick-up.
   c. Provide a wireless lavalier system for instructor voice pick-up. Both the ceiling-mounted microphone and wireless lavalier system will be fed into the assistive listening system and lecture capture system but not through the ceiling loudspeakers.
   d. Provide a digital signal processor.
   e. Provide an audio amplifier with a security cover to prevent tampering.
   f. Provide an assistive listening system as required to meet ADA guidelines.
   g. Route ceiling-mounted microphones and program audio to the assisted listening system.

3. Video System
   a. Provide a ceiling-mounted video projector on a fixed mounting pole.
   b. Provide projector mount and pole.
   c. Provide a wall-mounted display and associated mount that will serve as a confidence monitor.
   d. Provide a display at the instructor’s desk that will serve as a confidence monitor.
   e. Provide a video switcher.
   f. Provide an HDMI distribution amplifier.
   g. Provide scaling HDBaseT transmitters and receivers.
   h. Provide wall-mounted PTZ cameras and associated mounts.
   i. Provide an HDMI switch to select the PTZ camera that is being sent to the lecture capture device.
   j. Provide a camera HDBaseT receiver.
   k. Provide a networked lecture capture device. Coordinate with Owner on lecture capture device user interface.
   l. Provide a Blu-ray player in the equipment rack.
   m. Provide a document camera at the instructor position.
   n. Provide 12 ft HDMI, VGA, USB, and 3.5mm audio connectors at the lectern.
   o. Provide a composite video input, including stereo audio, with user-accessible cabling, coiled neatly inside the equipment rack to support an Owner-furnished VHS player.
   p. Install an Owner-furnished PC in the equipment rack.

4. Control System
   a. Provide a lectern-mounted, hard button remote control for system control.
   b. Provide a networked room controller.
   c. Controls should include but are not limited to audio volume up/down and mute, input source selections, PTZ camera presets, standard Blu-ray device controls and the ability to navigate media device menus.
5. Miscellaneous
   a. Provide a technology lectern with an integrated equipment rack for the audiovisual system headend.

E. General Lab

1. General
   a. This room type applies to the following rooms: Anatomy Lab, Physio Lab, Microbio Lab, Computer Lab, Gen Bio Lab, O-Chem Lab, General Chemistry, Intro Chem Lab, Engineering Lab and Physics Lab.
   b. Instructional space designed for lab-style presentations.
   c. The projector will display content as selected by the user via the push-button controller.
   d. The confidence monitors will duplicate any displayed source as selected by the user.
   e. A local confidence monitor will be located at the instructor desk.
   f. Provide camera presets on control panels. Coordinate with the Owner to determine and program these presets.

2. Audio System
   a. Provide ceiling loudspeakers for program audio.
   b. Provide ceiling-mounted microphones for instructor voice pick-up.
   c. Provide a wireless lavalier system for instructor voice pick-up. Both the ceiling-mounted microphone and wireless lavalier system will be fed into the assistive listening system and lecture capture system but not through the ceiling loudspeakers.
   d. Provide a digital signal processor.
   e. Provide an audio amplifier with a security cover to prevent tampering.
   f. Provide an assistive listening system to meet ADA requirements.

3. Video System
   a. Provide a ceiling-mounted video projector on a fixed mounting pole.
   b. Provide projector mount and pole.
   c. Provide an interactive short throw projector.
   d. Provide a wall-mounted display and associated mount that will serve as a confidence monitor.
   e. Provide a display at the instructor’s desk that will serve as a confidence monitor.
   f. Provide a video switcher.
   g. Provide an HDMI distribution amplifier.
   h. Provide scaling HDBT transmitters and receivers.
   i. Provide wall-mounted PTZ cameras and associated mounts.
   j. Provide an HDMI switch to select the PTZ camera that is being sent to the lecture capture device.
   k. Provide a camera HDBaseT receiver.
   l. Provide a networked lecture capture device. Coordinate with Owner on lecture capture device user-interface.
   m. Provide a Blu-ray player in the equipment rack.
   n. Provide a document camera at the instructor position.
   o. Provide 12 ft HDMI, VGA, USB, and 3.5mm audio connectors at the lectern. In locations where the equipment rack is remote from the lectern, provide extender for each cable on the lectern.
   p. Provide a composite video input, including stereo audio, with user-accessible cabling, coiled neatly inside the equipment rack to support an Owner-furnished VHS player.
   q. Install an Owner-furnished PC in the equipment rack.
4. Control System
   a. Provide a lectern mounted, hard button remote control for system control.
   b. Provide a networked room controller.
   c. Controls should include but are not limited to audio volume up/down and mute, input source selections, PTZ camera presets, standard media device controls and the ability to navigate media device menus.

5. Miscellaneous
   a. Provide an equipment rack.
   b. Provide a USB transmitter and receiver.

1.6 SUBMITTALS
   A. Comply with the Submittal requirements in Section 270000.
   B. Bid submittal Submit bids in accordance with project’s overall bidding requirements, and include the following requirements of this section.

1. Firm information and qualifications: Include detailed information about the firm, including but not limited to the following, in the bid:
   a. Firm’s history – how long the firm has been in business, how long the firm has offered audiovisual systems integration services, etc.
   b. Annual revenue for the three most current years
   c. Bonding capacity and bonding insurance agent contact information
   d. Three successfully completed projects of similar scope within the past 24 months. For each project, include the owner/client name, contact information (person's name, position, and telephone number or email address), project location, type of systems installed, total contract amount, date completed, and services included (e.g., engineering, installation, integration, maintenance, etc.).
   e. Industry affiliations
   f. Advanced certifications (CTS-I/D, DMC-D/E, ACE-D/I/P/RMS, XTP, etc.)
   g. Manufacturer certifications
   h. Contractor license number for the state where the work will take place
   i. Union affiliation(s)

2. Personnel and certifications: Include information on key personnel in the bid.
   a. Include résumés and certifications for personnel who will be assigned to the project including but not limited to the Project Manager, Systems Engineer, Field Installation Supervisor, Lead Control System Programmer, and other key personnel.
   b. Include résumé(s) of CTS–I (Certified Technology Specialist – Installation) certified personnel
   c. Include other relevant company-held industry, manufacturer, and educational certifications and designations for involved personnel


4. Schedule of values: Include a schedule of values in the bid. Break out the schedule of values into two areas – equipment costs and non-equipment costs.
   a. Equipment costs: List equipment costs (each piece of equipment), including required modifications and accessories.
b. Non-equipment costs: List non-equipment costs, such as the following:
   1) General and Administrative: shipping, insurance, and guarantees, etc.
   2) Fees: e-Waste/disposal, permits, etc.
   3) Engineering: design, drawings, run sheets, instruction manuals, etc.
   4) Pre-installation: fabrication, modification, assembly, rack wiring, etc.
   5) Installation: installation, coordination, supervision, testing, etc.

6) Owner training: training session(s), manuals, etc.

5. Alternates/substitutions: Refer to Section 270000 for alternate and substitution requirements. Submit bids based on the specified equipment. If the bid includes proposed alternates and/or substitutes, separate these from the costs of the equipment as specified and include for alternate equipment full technical information and cut sheets. Proposed alternate equipment will receive consideration if the differences between the specified and alternate/substituted equipment do not depart from the design intent and function of the system and are in the best interests of the Owner. If the inclusion of substituted equipment will result in a different connection configuration than that in the bid documents, include drawings that illustrate how the proposed system would be connected.

6. System enhancements: Include in the bid recommendations, if any, that will enhance the performance and/or functionality of the system, or will reduce costs without loss of performance/functionality. Recommendations that are of value to the Owner will be taken into consideration in the evaluation of the bids. Make such proposed recommendations as “alternates”, with the appropriate cost modifications shown separate and apart from the costs of the system “as specified”.

7. Exceptions: In the bid, explain exceptions, if any, to these specifications and related drawings. In the absence of exceptions, these specifications and related drawings are binding in letter and intent.

8. Guarantee compliance with requirements and regulations in effect on the job site. Explicitly state any such non-compliances or conflicts in the bid submittal. The bidder has the responsibility to investigate potential contract, union, and scheduling issues, and to notify the general contractor of such.

C. Pre-construction submittals

1. Product data: Prior to purchase and installation, submit as a PDF file, information (such as cut sheets, etc.) for equipment, components, products, etc., that will be installed as part of the work of this section.
   a. Include in the submittal, a Table of Contents, listing equipment, components, products, etc., by room, by system, and/or by other logical designation. A continuous list of all products with no reference to where the products will be installed will be rejected. Incomplete lists will be rejected.
   b. Indicate (arrow, highlight or other designator) on each product’s cut sheet the manufacturer, model/part number, accessories (as applicable), options (as applicable), color (as applicable), and other information to indicate the exact item to be installed. Where this information is not already provided on the cut sheet, manually input this information and a brief description (as applicable).
2. Substitutions [refer to Section 270000 for substitution requirements]: Submit substitution requests based on the specified equipment and including associated equipment costs separate from the costs of the equipment as specified.
   a. Proposals for alternate equipment will receive consideration if the differences between the specified and alternate/substituted equipment do not depart from the overall intent of the design and operation of the system and are in the best interests of the Owner.
   b. Include full technical information and cut sheets for the proposed substitutions.
   c. If the inclusion of substituted equipment will result in a different connection configuration than that in the bid documents, produce drawings that illustrate how the proposed system would be connected.

3. Shop drawings [refer to Section 270000 for additional shop drawing requirements]:
   Submit shop drawings prior to installation and in accordance with the Conditions of Contract and Division 1, including the following.
   a. Functional line diagrams for all systems – clearly tag each item with name, manufacturer, and manufacturer’s model number (e.g., “Program Amplifier LabGruppen LUCIA 60/2M”) and show the terminal number or input/output designation (e.g., “Mic 1-In”, or “Record Out-Left”).
   b. Provide schematic diagrams of custom circuitry such as receptacle pin numbers and component callouts; show details of custom resistive attenuation and/or combining networks, filters, or pads which may be required in the assembly; show point to point wiring drawings for control system modules and interfaces, and for switches and relays in audio, video, or control systems.
   c. Equipment rack elevations and patch panel assignments – clearly and consistently label rack elevations, patch panels, and on equipment controls.
   d. Provide pushbutton and handheld remote control panel layouts – tag each button with function and ID matching installed labels.
   e. Factory and custom panels, plates, and designation strips, showing material, finish, color and engraving (exact lettering).
   f. Custom designed consoles, tables, carts, support bases, and shelves.
   g. Equipment modifications (if any), including details of modifications that change or void manufacturers' warranties.
   h. Cable run lists – clearly show at each terminal point the type of connector to be used; include typical wiring details of each connector; note where shields are connected and where they will float to ensure the integrity of the shielding system; indicate cable types and, where appropriate, color codes; assign wire numbers and patch bay locations to every wire and patch point in the drawing.
   i. Wattage tap setting per loudspeaker.

4. Button controller submittal:
   a. Provide a PDF per system containing a page for layout of all buttons. Ensure that the PDF is unlocked so that the Engineer may annotate it.

5. Network coordination: Submit as an Excel file or cloud-based collaborative spreadsheet (such as Google Sheets) a list of equipment that will be connected to the network, including but not limited to the following (e.g., spreadsheet column headers):
   a. Item number
   b. Description
   c. Manufacturer
   d. Model/part number
   e. MAC address
   f. IP address type (DHCP or static)
   g. Power-over-Ethernet (PoE) requirements (yes or no; which PoE standard)
   h. Specific network and/or subnet configuration requirements
i. Specific QOS requirements
j. Anticipated network traffic

6. Testing equipment and procedures:
a. Submit a list of test equipment, including manufacturer, model number, and description that will be used for testing and adjustment of the installed systems.
b. Submit testing procedures to be performed during pre-functional testing and acceptance testing, including the minimum acceptable outcome for each test.

D. At the completion of the installation

1. Initial Testing and Tuning Report: After completing initial testing and tuning, checkout, settings, as-built drawings, and operational documentation, submit written notification to the Owner and Architect that initial checkout is complete. Include in this notification a completed Initial Testing and Tuning Report that satisfies the requirements of Part 3. In the Report, document the results for tests performed during initial testing and tuning. Organize the report per room, per system, and per test. Include the testing tools/equipment, manual and automated tests, testing procedures, and expected result per test. If the test equipment stores test results and has the capability to produce reports, also include these reports.

2. Wireless microphones frequencies. Submit a list of wireless microphone frequencies and associated channels used for each microphone and system.

E. Closeout Submittals

1. Acceptance Testing Report: After completing final acceptance testing, final tuning and settings, submit an Acceptance Testing Report that documents the results for tests performed during final testing and tuning. Organize the report per room, per system, and per test. Include the testing tools/equipment, manual and automated tests, testing procedures, and expected result per test. If the test equipment stores test results and has the capability to produce reports, also include these reports. Include the system’s normal settings.

2. As-built drawings [refer to Section 270000 for additional as-built drawing requirements]: Submit as-built drawings in accordance with the Conditions of Contract and Division 1, including the following.

   a. System functional line drawings for all systems; clearly tag each item with name, manufacturer, and manufacturer’s model number (e.g., “Program Amplifier Lab.Gruppen LUCIA 60/2M”) and show the terminal number or input/output designation (e.g., “Mic 1-In”, or “Record Out-Left”).
   b. Point-to-point wiring diagrams for switches and relays in audio, video, and control systems; point-to-point wiring diagram for control system modules and interfaces
   c. Schematic diagrams of custom circuitry such as receptacle pin numbers and component callouts; show details of custom resistive attenuation and/or combining networks, filters, or pads which may be required in the assembly
   d. Equipment rack elevations and patch panel assignment drawings. Clearly label the rack elevations, patch panels, and equipment controls.
   e. Cable run lists – clearly show at each terminal point the type of connector to be used; include typical wiring details of each connector; note where shields are connected and where they will float to ensure the integrity of the shielding system; indicate cable types and, where appropriate, color codes; assign wire numbers and patch bay locations to every wire and patch point in the drawing
   f. Pushbutton and handheld remote-control panel layouts, including tagging each button with function and ID that matches installed labels
   g. Factory and custom panels, plates, and designation strips, showing material, finish, color and engraving (exact lettering)
   h. Wattage tap setting per loudspeaker.
3. System Operation and Maintenance (O&M) manual:
   a. Describe typical procedures necessary to activate each system for full functionality as required under the System Description.
   b. Describe normal settings for equalizer, amplifier, signal processing, and user operated controls (as established during system check out) in tabular or pictorial form.
   c. Outline a recommended maintenance schedule with reference to the applicable pages in the manufacturer’s maintenance manuals. Where inadequate maintenance information is provided by the manufacturer, provide the information necessary for proper maintenance.
   d. Outline a recommended plan for a normal maintenance period of at least one year, including a list of necessary and recommended replacement parts.
   e. Assume the reader of this manual to be technically competent, but unfamiliar with this particular facility.
   f. Submit equipment manufacturers’ operation and maintenance manuals for each piece of equipment.

4. Programming/software:
   a. Submit the project’s control system programming and audio processor configuration files – refer to “Software License” below.

1.7 QUALITY ASSURANCE

A. Audiovisual Contractor requirements: Demonstrate that your firm meets or exceeds the following requirements:

1. Five years’ experience, minimum, with the design, engineering, assembly, installation, start-up and maintenance of audiovisual systems of similar or greater complexity to those identified in this specification
2. Provide the necessary professional design, engineering, fabrication, installation, and project management personnel to execute the work of this section, and to guarantee a complete, functional system in compliance with the design intent
3. Successfully completed in the past 24 months a minimum of three projects of similar scope
4. Current state contracting license, as required to perform the work under this section
5. Bondable to 100% of contract value
6. Be an authorized supplier and installer for equipment listed in this section
7. Maintain permanent fabrication, service and support facilities within 100 miles of the Project site.
B. Audiovisual Contractor certifications: Demonstrate that your firm has the following certifications:
   1. An InfoComm CTS-I (Certified Technology Specialist-Installation) certified employee to actively manage this project – the Engineer will verify CTS credentials at the InfoComm website.

C. Manufacturer/equipment supplier requirements: Demonstrate that your firm meets or exceeds the following:
   1. Operate their business for not less than five years

D. Subcontractor quality:
   1. Specifically identify in the bid submission, for Owner, Architect, or Engineer’s approval, all subcontractors that will be used.
   2. Regardless of any subcontract arrangement, your firm will have sole responsibility for the successful implementation of the work in this section.

1.8 PROJECT MANAGEMENT AND COORDINATION

   A. Comply with the Project Management requirements in Section 270000.
   B. Assign a project manager to this project for the entire duration. They shall oversee the design, submittals, implementation, testing, and close out – the entire process from start to finish. The project manager shall also coordinate this work of this section with other trades.

1.9 DELIVERY, STORAGE AND HANDLING

   A. Comply with Delivery, Storage and Handling requirements in Section 270000.

1.10 WARRANTY

   A. Warrant the System for a minimum of one year from the date of system acceptance by the Owner. Honor component warranties per manufacturers’ terms if greater than one year.
      1. Include service as described in 3.14 “Maintenance and Extended Service” in the warranty.
   
   B. Activate manufacturers’ equipment warranties in the Owner’s name. The warranty period shall commence on the date of System Acceptance by the Owner.
      1. In the case of contractor-modified equipment (where the manufacturer’s warranty could be voided), warrant such equipment equivalent to that of the original manufacturer.

   C. Warrant the Software and version updates – see “Software” below.
1.11 SOFTWARE LICENSE

A. Nondisclosure

1. During or after the termination of this Agreement, the Owner agrees not to disclose any proprietary information provided by the AV Contractor, to maintain such information as confidential and not use such information provided in Project documents for any purpose other than maintenance and support of in-house systems. This does not apply to any of the information that becomes generally known to the public due to publication or other legal means and through no fault of the Owner.

B. Obligations governing the Software

1. The AV Contractor shall own the copyright of any custom created software/parameter files ("Software") and hereby grants the Owner a royalty-free, non-exclusive license to use the Software for use with the audiovisual and other connected systems in this project. This license cannot be transferred.
2. The Owner shall not rent, loan or re-license rights to use the Software to any third party.
3. Any Third-party software provided or made available to the Owner by the AV Contractor, but not created by the AV Contractor, is sublicensed to the Owner through the AV Contractor. The AV Contractor agrees that such sublicense is granted with consent of the third-party at no cost to the Owner, and the Owner shall be entitled to use such software under the same terms as the AV Contractor.
4. The AV Contractor and third-party suppliers are not restricted from licensing the Software or any portion thereof to other customers.
5. At acceptance testing, provide the source code for custom created software, applications required to use the source code, descriptions of the required equipment, and instructions detailing the modification and installation of the Software to the Owner.

C. For project and custom Software, the following apply.

1. Provide the source code to the Owner either directly via file transfer or make it available through other means, such as cloud storage, an FTP site, etc. Maintain older versions within a folder structure and make them available to the Owner at the Owner's request. At the end of the warranty period, release the current and older versions of the source code to the Owner. If the AV contractor ceases to exist during the warranty period, release the source code to the Owner upon termination of the business.
2. Provide the Software in a form suitable for immediate access by the System.
3. The AV contractor grants the Owner the right to modify and to enhance the Software as furnished and licensed under the terms of this Agreement at its own risk and expense, and further agrees such modifications and enhancements developed by the Owner to be the property of the Owner. Any changes to the custom created software parameter files do not affect copyright ownership.
4. During the warranty period, if the Owner discovers that the Software is no longer functioning in the same manner as had been approved at the beginning of the warranty period, they shall document the fault in sufficient detail to allow errors to be reproduced, and they will notify the AV contractor. Within two business days of this notification, update the software, provide or post updated Software files as detailed above, demonstrate that the error has been resolved, and maintain updated Software files as detailed above.
5. Defend any suit brought against the Owner and pay any damages due to the resulting judgment from any suit brought against the Owner as it pertains to a violation of copyrights or patents of the Software or licenses. The Owner shall notify the AV contractor in writing promptly and give authority, information and assistance at the AV Contractor’s expense.
6. The AV contractor at its own expense and option shall, if able, procure for the Owner the right to continue to use the Software as licensed or to replace it with a non-infringing release. This shall not include any agreement by the AV Contractor to accept liability for patent or copyright infringement for beyond the Software as licensed and furnished for the Project. This also excludes any agreement by the AV contractor to accept liability for patent or copyright infringements for methods and processes to be carried out by using said Software except those inherent in the furnished System.

7. All contracts with Third-party software suppliers will transfer from the AV Contractor to the Owner at Project acceptance by the Owner.

8. The Owner shall apprise the AV Contractor of activities it takes with Third-party software providers during the warranty period. Included activities would include discontinuing the use of any Software component, installing updated or alternate versions of the Software, revising the configuration of affected systems.

9. The Owner can contact the AV Contractor for questions at no additional cost during the warranty period, providing:
   a. The queries are related to the audiovisual systems defined in this document.
   b. The query is asked by the Owner’s staff or authorized representative.
   c. The inquirer has attended the AV Contractor’s or the manufacturer’s training in the use of the systems defined in this document.
   d. The question is not intended as design consultation.

10. The Owner can only make copies as backup files of the Software and they are required to include the AV Contractor’s copyright notice. The Owner shall make a reasonable effort to secure this Software to prevent theft or unlicensed usage.

D. Software license terms
   1. The Software license is granted by the AV Contractor for the devices provided for the Systems. If any devices in the system fails, the license can be transferred to a replacement device on a temporary or permanent basis if the original device is to be phased out. The transference may only occur with written notification to the AV Contractor.
   2. Additional licenses or changes to the Software are subject to a supplemental agreement between the AV Contractor and the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. Comply with the Products requirements in Section 270000.
B. Provide products, equipment and software that are the latest version of the specified model or type available at the time of procurement, providing the updated devices provide the same or better capabilities and performance required by the system design.
C. Equipment make/model numbers that specified represents minimum performance criteria for each function.
D. Substitutions: The engineer may consider substitutions for certain equipment if the Contractor demonstrates that the substitution meets or exceeds the functional requirements described in the System Description and Performance Standards. Follow the requirements of section 012500 "Substitutions" for substitution requests.
2.2 EQUIPMENT SCHEDULE

A. Quantities: Quantities are either listed herein with a number, as "A/S" (as shown), or as "A/R" (as required). If listed as A/R or the quantity is marked with an asterisk, determine quantities as required for a fully operational system. Confirm the quantity listed here against the drawings.
### 72 OCC Classroom

<table>
<thead>
<tr>
<th>Description</th>
<th>Make</th>
<th>Model</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling loudspeakers</td>
<td>Extron</td>
<td>SF 3CT LP</td>
<td></td>
</tr>
<tr>
<td>Ceiling-mounted microphones</td>
<td>Audio-Technica</td>
<td>Pro 45W</td>
<td></td>
</tr>
<tr>
<td>Wireless lavalier microphone</td>
<td>Shure</td>
<td>SLX14/93</td>
<td>J3 Band. Install antennas at the front of the rack.</td>
</tr>
<tr>
<td>Digital signal processor</td>
<td>Extron</td>
<td>DMP 64</td>
<td></td>
</tr>
<tr>
<td>Audio amplifier</td>
<td>TOA</td>
<td>P-912MK2</td>
<td>Include rack-mounting brackets</td>
</tr>
<tr>
<td>Audio amplifier</td>
<td>TOA</td>
<td>BA-260</td>
<td></td>
</tr>
<tr>
<td>Security cover</td>
<td>Middle Atlantic</td>
<td>S3</td>
<td>Install using security bolts. Provide the Owner with a tool for the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>security bolts.</td>
</tr>
<tr>
<td>Assistive listening system –</td>
<td>Listen</td>
<td>LA-304</td>
<td>Quantity – 1. Coordinate placement with Architect</td>
</tr>
<tr>
<td>signage kit</td>
<td>Technologies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assisted listening system –</td>
<td>Listen</td>
<td>LT-800-072-01</td>
<td>Locate in local AV rack; include Universal Antenna Kit #LA-122 and</td>
</tr>
<tr>
<td>RF transmitter</td>
<td>Technologies</td>
<td></td>
<td>Rack Kit #LA-326.</td>
</tr>
<tr>
<td>Video projector</td>
<td>Panasonic</td>
<td>PT-RZ370U</td>
<td></td>
</tr>
<tr>
<td>Projector mount (fixed pole</td>
<td>Chief</td>
<td>RPMx Series</td>
<td>Pole length as required. Provide quantity as required for system</td>
</tr>
<tr>
<td>w/ lock)</td>
<td></td>
<td></td>
<td>operation.</td>
</tr>
<tr>
<td>Wall-mounted Display</td>
<td>LG</td>
<td>65UU340C</td>
<td>Confidence monitor</td>
</tr>
<tr>
<td>Display mount</td>
<td>Chief</td>
<td>TS525TU</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Display (table)</td>
<td>LG</td>
<td>28LJ4540</td>
<td>Confidence monitor</td>
</tr>
<tr>
<td>Video matrix switcher</td>
<td>Kramer</td>
<td>VP-773A</td>
<td>Locate at lectern</td>
</tr>
<tr>
<td>HDMI distribution amplifier</td>
<td>Kramer</td>
<td>VM-2H2</td>
<td></td>
</tr>
<tr>
<td>HDBT distribution amplifier</td>
<td>Kramer</td>
<td>VM-2DT</td>
<td></td>
</tr>
<tr>
<td>HDBT HDMI TX</td>
<td>Kramer</td>
<td>TP – 580T</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>HDBT HDMI RX</td>
<td>Kramer</td>
<td>TP – 580RXR</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Wall-mounted PTZ camera</td>
<td>Marshall</td>
<td>CV612HT-4K</td>
<td>Coordinate finish with Owner.</td>
</tr>
<tr>
<td>Description</td>
<td>Make</td>
<td>Model</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>----------------</td>
<td>-------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Camera mount</td>
<td>Kramer</td>
<td>VS-211UHD</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Networked lecture capture device</td>
<td>Epiphon</td>
<td>Mini</td>
<td></td>
</tr>
<tr>
<td>Blu-ray player</td>
<td>Sony</td>
<td>BDP-S3200</td>
<td></td>
</tr>
<tr>
<td>Rack shelf</td>
<td>Middle Atlantic</td>
<td>RSH-series</td>
<td></td>
</tr>
<tr>
<td>Document camera</td>
<td>Elmo, or equal</td>
<td>TT-12iD</td>
<td></td>
</tr>
<tr>
<td>PC</td>
<td>OFCI</td>
<td>OFCI</td>
<td>Provide a Middle Atlantic RSH4A3M configured for the selected PC. Coordinate with Owner on PC model. Install rack shelf with security screws.</td>
</tr>
<tr>
<td>VHS player (portable)</td>
<td>OFOI</td>
<td>OFOI</td>
<td>Provide rack shelf</td>
</tr>
<tr>
<td>Lectern-mounted button control panel</td>
<td>SP Controls</td>
<td>PX2-MP-IR</td>
<td>Quantity – 1. Integrate into the lectern</td>
</tr>
<tr>
<td>Networked room controller</td>
<td>SP Controls</td>
<td>PX2-NRC-1142</td>
<td>Include PX2-PUC-232/IR modules A/R. Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Control module</td>
<td>SP Controls</td>
<td>PX2-PUC-232/IR</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Control module</td>
<td>SP Controls</td>
<td>PX2-PUC-IR-4</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Power conditioner/sequencer</td>
<td>Furman</td>
<td>CN-1800S</td>
<td></td>
</tr>
<tr>
<td>Technology lectern</td>
<td>Spectrum</td>
<td>Freedom One E-Lift</td>
<td>Quantity – 1. Part #55357-GTBKDB201120110. Include FPM monitor arm.</td>
</tr>
<tr>
<td>Sliding rackshelf</td>
<td>Middle Atlantic</td>
<td>SS4-23VTR</td>
<td>Quantity – 1. Used to support the document camera</td>
</tr>
</tbody>
</table>

C. Biotech Lab

<table>
<thead>
<tr>
<th>Description</th>
<th>Make</th>
<th>Model</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling loudspeakers</td>
<td>Extron</td>
<td>SF 3CT LP</td>
<td></td>
</tr>
<tr>
<td>Ceiling-mounted microphones</td>
<td>Audio-Technica</td>
<td>Pro 45W</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>Make</td>
<td>Model</td>
<td>Notes</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>--------------</td>
<td>--------------------</td>
<td>---------------------------------------------------------</td>
</tr>
<tr>
<td>Wireless lavalier microphone</td>
<td>Shure</td>
<td>SLX14/93</td>
<td>J3 Band</td>
</tr>
<tr>
<td>Digital signal processor</td>
<td>Extron</td>
<td>DMP 64</td>
<td></td>
</tr>
<tr>
<td>Audio amplifier</td>
<td>TOA</td>
<td>P-912MK2</td>
<td>Include rack-mounting brackets</td>
</tr>
<tr>
<td>Security cover</td>
<td>Middle Atlantic</td>
<td>S3</td>
<td>Install using security bolts</td>
</tr>
<tr>
<td>Assistive listening system – signage kit</td>
<td>Listen</td>
<td>LA-304</td>
<td>Quantity – 1. Coordinate placement with architect</td>
</tr>
<tr>
<td>Assisted listening system – RF transmitter</td>
<td>Listen</td>
<td>LT-800-072-01</td>
<td>Locate in local AV rack; include Universal Antenna Kit #LA-122 and Rack Kit #LA-326.</td>
</tr>
<tr>
<td>Ceiling-mounted video projector</td>
<td>Panasonic</td>
<td>PT-RZ370U</td>
<td></td>
</tr>
<tr>
<td>Projector mount (fixed pole w/ lock)</td>
<td>Chief</td>
<td>RPMx Series</td>
<td>Pole length as required. Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Display (table)</td>
<td>LG</td>
<td>28LJ4540</td>
<td>Confidence monitor</td>
</tr>
<tr>
<td>Video switcher</td>
<td>Kramer</td>
<td>VP-773A</td>
<td></td>
</tr>
<tr>
<td>HDMI distribution amplifier</td>
<td>Kramer</td>
<td>VM-2H2</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>HDMI switcher</td>
<td>Kramer</td>
<td>VS-81H</td>
<td></td>
</tr>
<tr>
<td>VGA to HDMI converter</td>
<td>Kramer</td>
<td>VP-425</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>HDBT HDMI TX</td>
<td>Kramer</td>
<td>TP – 580T</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>HDBT HDMI RX</td>
<td>Kramer</td>
<td>TP – 580RXR</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>HDMI Receiver</td>
<td>Kramer</td>
<td>PT-872xr</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Camera mounts</td>
<td>Marshall</td>
<td>CV6XX-WMx</td>
<td>Confirm finish with Architect.</td>
</tr>
<tr>
<td>HDMI switch</td>
<td>Kramer</td>
<td>VS-211UHD</td>
<td></td>
</tr>
<tr>
<td>Camera HDBaseT receiver</td>
<td>Marshall</td>
<td>VAC-HT48-POE-R</td>
<td></td>
</tr>
<tr>
<td>Networked lecture capture device</td>
<td>Epiphan</td>
<td>Mini</td>
<td></td>
</tr>
</tbody>
</table>
## D. Meeting Room

<table>
<thead>
<tr>
<th>Description</th>
<th>Make</th>
<th>Model</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall-mounted display</td>
<td>LG</td>
<td>65UU340C</td>
<td></td>
</tr>
<tr>
<td>Display mount</td>
<td>Chief</td>
<td>TS525TU</td>
<td>Locate in credenza</td>
</tr>
<tr>
<td>Video switcher</td>
<td>Kramer</td>
<td>VP-440H2</td>
<td></td>
</tr>
<tr>
<td>HDBaseT HDMI RX</td>
<td>Kramer</td>
<td>TP – TP-580RXR</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>HDBaseT Auto switch</td>
<td>Kramer</td>
<td>DIP-20</td>
<td></td>
</tr>
<tr>
<td>Conferencing soundbar with camera</td>
<td>Logitech</td>
<td>Meetup</td>
<td>Install with extension mic</td>
</tr>
<tr>
<td>Blu-ray player</td>
<td>Sony</td>
<td>BDP-S3200</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>Make</td>
<td>Model</td>
<td>Notes</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>---------------</td>
<td>----------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>PC</td>
<td>OFCI</td>
<td>OFCI</td>
<td>Provide a Middle Atlantic RSH4A3M configured for the selected PC. Coordinate with Owner on PC model. Install rack shelf with security screws.</td>
</tr>
<tr>
<td>Wall-mounted button control panel</td>
<td>SP Controls</td>
<td>PX2-MP-IR</td>
<td>Quantity - 1</td>
</tr>
<tr>
<td>Networked room controller</td>
<td>SP Controls</td>
<td>PX2-NRC-1142</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Control module</td>
<td>SP Controls</td>
<td>PX2-PUC-232/IR</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Acrylic enclosure</td>
<td>SP Controls</td>
<td>PX2-PL-xx</td>
<td>Coordinate finish with Owner.</td>
</tr>
<tr>
<td>USB transmitter</td>
<td>Extron</td>
<td>USB Extender Plus T</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>USB receiver</td>
<td>Extron</td>
<td>USB Extender Plus T</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Equipment rack</td>
<td>Middle Atlantic</td>
<td>CFR-13-16</td>
<td>Quantity - 1</td>
</tr>
</tbody>
</table>

### E. General Classroom

<table>
<thead>
<tr>
<th>Description</th>
<th>Make</th>
<th>Model</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling loudspeakers</td>
<td>Extron</td>
<td>SF 3CT LP</td>
<td></td>
</tr>
<tr>
<td>Ceiling-mounted microphones</td>
<td>Audio-Technica</td>
<td>Pro 45W</td>
<td></td>
</tr>
<tr>
<td>Wireless lavali er microphone</td>
<td>Shure</td>
<td>SLX14/93</td>
<td>J3 Band. Install antennas at the front of the rack.</td>
</tr>
<tr>
<td>Digital signal processor</td>
<td>Extron</td>
<td>DMP 64</td>
<td></td>
</tr>
<tr>
<td>Audio amplifier</td>
<td>TOA</td>
<td>P-912MK2</td>
<td>Include rack-mounting brackets</td>
</tr>
<tr>
<td>Security cover</td>
<td>Middle Atlantic</td>
<td>S3</td>
<td>Install using security bolts</td>
</tr>
<tr>
<td>Assistive listening system – signage kit</td>
<td>Listen Technologies</td>
<td>LA-304</td>
<td>Quantity – 1. Coordinate placement with architect</td>
</tr>
<tr>
<td>Assisted listening system – RF transmitter</td>
<td>Listen Technologies</td>
<td>LT-800-072-01</td>
<td>Locate in local AV rack; include Universal Antenna Kit #LA-122 and Rack Kit #LA-326. Install antenna in front of the rack.</td>
</tr>
<tr>
<td>Item Description</td>
<td>Brand</td>
<td>Model</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td>-------------</td>
<td>---------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ceiling-mounted video projector</td>
<td>Panasonic</td>
<td>PT-RZ370U</td>
<td></td>
</tr>
<tr>
<td>Projector mount (fixed pole w/ lock)</td>
<td>Chief</td>
<td>RPMx Series, or Equal</td>
<td>Pole length as required. Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Wall-mounted display</td>
<td>LG</td>
<td>65UU340C</td>
<td>Confidence monitor</td>
</tr>
<tr>
<td>Display mount</td>
<td>Chief</td>
<td>TS525TU</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Display (table)</td>
<td>LG</td>
<td>28LJ4540</td>
<td>Confidence monitor</td>
</tr>
<tr>
<td>Video matrix switcher</td>
<td>Kramer</td>
<td>VP-773A</td>
<td></td>
</tr>
<tr>
<td>HDMI distribution amplifier</td>
<td>Kramer</td>
<td>VM-2H2</td>
<td></td>
</tr>
<tr>
<td>HDBaseT HDMI TX</td>
<td>Kramer</td>
<td>TP – 580T</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>HDBaseT HDMI RX</td>
<td>Kramer</td>
<td>TP – 580RXR</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Wall-mounted PTZ camera</td>
<td>Marshall</td>
<td>CV612HT-4K</td>
<td>Coordinate finish with Owner.</td>
</tr>
<tr>
<td>Camera mount</td>
<td>Marshall</td>
<td>CV6XX-WMx</td>
<td>Confirm finish with Owner.</td>
</tr>
<tr>
<td>HDMI switch</td>
<td>Kramer</td>
<td>VS-211UHD</td>
<td></td>
</tr>
<tr>
<td>Camera HDBaseT receiver</td>
<td>Marshall</td>
<td>VAC-HT48-POE-R</td>
<td></td>
</tr>
<tr>
<td>Networked lecture capture device</td>
<td>Epiphan</td>
<td>Mini</td>
<td></td>
</tr>
<tr>
<td>Blu-ray player</td>
<td>Sony</td>
<td>BDP-S3200</td>
<td></td>
</tr>
<tr>
<td>Rack shelf</td>
<td>Middle Atlantic</td>
<td>RSH-series</td>
<td></td>
</tr>
<tr>
<td>Document camera</td>
<td>Elmo, or equal</td>
<td>TT-12iD, or equal</td>
<td></td>
</tr>
<tr>
<td>PC</td>
<td>OFCI</td>
<td>OFCI</td>
<td>Provide a Middle Atlantic RSH4A3M configured for the selected PC. Coordinate with Owner on PC model. Install rack shelf with security screws.</td>
</tr>
<tr>
<td>VHS player (portable)</td>
<td>OFOI</td>
<td>OFOI</td>
<td>Provide rack shelf</td>
</tr>
<tr>
<td>Lectern-mounted button control panel</td>
<td>SP Controls</td>
<td>PX2-MP-IR</td>
<td>Quantity – 1. Integrate into the lectern</td>
</tr>
<tr>
<td>Networked room controller</td>
<td>SP Controls</td>
<td>PX2-NRC-1142</td>
<td></td>
</tr>
<tr>
<td>Control module</td>
<td>SP Controls</td>
<td>PX2-PUC-232/IR</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Description</td>
<td>Make</td>
<td>Model</td>
<td>Notes</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------------------</td>
<td>---------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Control module</td>
<td>SP Controls</td>
<td>PX2-PUC-IR-4</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Power conditioner/sequencer</td>
<td>Furman</td>
<td>CN-1800S</td>
<td></td>
</tr>
<tr>
<td>Technology lectern</td>
<td>Spectrum Industries</td>
<td>Freedom One E-Lift</td>
<td>Quantity – 1. Part #55357-GTBKDB20112011 0. Include FPM monitor arm.</td>
</tr>
<tr>
<td>Sliding rackshelf</td>
<td>Middle Atlantic</td>
<td>SS4-23VTR</td>
<td>Quantity – 1. Used to support the document camera</td>
</tr>
</tbody>
</table>

**F. General Lab**

<table>
<thead>
<tr>
<th>Description</th>
<th>Make</th>
<th>Model</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling loudspeakers</td>
<td>Extron</td>
<td>SF 3CT LP</td>
<td></td>
</tr>
<tr>
<td>Ceiling-mounted microphone</td>
<td>Audio-Technica</td>
<td>Pro 45W</td>
<td></td>
</tr>
<tr>
<td>Wireless lavalier microphone</td>
<td>Shure</td>
<td>SLX14/93</td>
<td>Eight G5 bands, Remainder H5</td>
</tr>
<tr>
<td>Digital signal processor</td>
<td>Extron</td>
<td>DMP 64</td>
<td></td>
</tr>
<tr>
<td>Audio amplifier</td>
<td>TOA</td>
<td>P-912MK2</td>
<td>Include rack-mounting brackets</td>
</tr>
<tr>
<td>Security cover</td>
<td>Middle Atlantic</td>
<td>S3</td>
<td>Install using security bolts</td>
</tr>
<tr>
<td>Assistive listening system – signage kit</td>
<td>Listen Technologies</td>
<td>LA-304</td>
<td>Quantity – 1. Coordinate placement with architect</td>
</tr>
<tr>
<td>Assisted listening system – RF transmitter</td>
<td>Listen Technologies</td>
<td>LT-800-072-01</td>
<td>Locate in local AV rack; include Universal Antenna Kit #LA-122 and Rack Kit #LA-326.</td>
</tr>
<tr>
<td>Ceiling-mounted video projector</td>
<td>Panasonic</td>
<td>PT-RZ370U</td>
<td></td>
</tr>
<tr>
<td>Interactive Short-throw projector</td>
<td>Epson</td>
<td>BrightLink 710Ui</td>
<td>Provide for physics lab and engineering lab only instead of Panasonic PT-RZ370U.</td>
</tr>
<tr>
<td>Projector mount (fixed pole w/ lock)</td>
<td>Chief</td>
<td>RPMx Series, or equal</td>
<td>Pole length as required. Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Wall-mounted display</td>
<td>LG</td>
<td>65UU340C</td>
<td>Confidence monitor</td>
</tr>
<tr>
<td>Description</td>
<td>Make</td>
<td>Model</td>
<td>Notes</td>
</tr>
<tr>
<td>------------------------------</td>
<td>----------</td>
<td>--------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Display mount</td>
<td>Chief</td>
<td>TS525TU</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Display (table)</td>
<td>LG</td>
<td>28LJ4540</td>
<td>Confidence monitor</td>
</tr>
<tr>
<td>Video matrix switcher</td>
<td>Kramer</td>
<td>VP-773A</td>
<td></td>
</tr>
<tr>
<td>HDMI distribution amplifier</td>
<td>Kramer</td>
<td>VM-2H2</td>
<td></td>
</tr>
<tr>
<td>HDBT HDMI TX</td>
<td>Kramer</td>
<td>TP – 580T</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>HDBT HDMI RX</td>
<td>Kramer</td>
<td>TP – 580RX</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Wall-mounted PTZ camera</td>
<td>Marshall</td>
<td>CV612HT-4K</td>
<td>Coordinate finish with Owner.</td>
</tr>
<tr>
<td>Camera mount</td>
<td>Marshall</td>
<td>CV6XX-WMx</td>
<td>Confirm finish with Owner.</td>
</tr>
<tr>
<td>HDMI switch</td>
<td>Kramer</td>
<td>VS-211UHD</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Camera HDBaseT receiver</td>
<td>Marshall</td>
<td>VAC-HT48-POE-R</td>
<td></td>
</tr>
<tr>
<td>Networked lecture capture device</td>
<td>Epiphan</td>
<td>Mini</td>
<td></td>
</tr>
<tr>
<td>Blu-ray player</td>
<td>Sony</td>
<td>BDP-S3200</td>
<td></td>
</tr>
<tr>
<td>Document camera</td>
<td>Elmo, or equal</td>
<td>TT-121D, or equal</td>
<td></td>
</tr>
<tr>
<td>VGA and audio transmitter</td>
<td>Kramer</td>
<td>TP-121xI</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>VGA and audio receiver</td>
<td>Kramer</td>
<td>TP-122xI</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>HDMI transmitter</td>
<td>Kramer</td>
<td>PT-580T</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>HDMI receiver</td>
<td>Kramer</td>
<td>TP-580R</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>PC</td>
<td>OFCI</td>
<td>OFCI</td>
<td>Provide a Middle Atlantic RSH4A3M configured for the selected PC.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coordinate with Owner on PC model. Install rack shelf with security</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>screws.</td>
</tr>
<tr>
<td>VHS player (portable)</td>
<td>OFOI</td>
<td>OFOI</td>
<td>Provide rack shelf</td>
</tr>
<tr>
<td>Lectern-mounted button control panel</td>
<td>SP Controls</td>
<td>PX2-MP-IR</td>
<td>Quantity – 1. Integrate into the lectern</td>
</tr>
<tr>
<td>Description</td>
<td>Make</td>
<td>Model</td>
<td>Notes</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------</td>
<td>---------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Networked room controller</td>
<td>SP Controls</td>
<td>PX2-NRC-1142</td>
<td></td>
</tr>
<tr>
<td>Control module</td>
<td>SP Controls</td>
<td>PX2-PUC-232/IR</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Control module</td>
<td>SP Controls</td>
<td>PX2-PUC-IR-4</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>Acrylic enclosure</td>
<td>SP Controls</td>
<td>PX2-PL-xx</td>
<td>Coordinate finish with Owner.</td>
</tr>
<tr>
<td>Technology lectern</td>
<td>Spectrum</td>
<td>Freedom One E-Lift</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td></td>
<td>Industries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sliding rackshelf</td>
<td>Middle Atlantic</td>
<td>SS4-23VTR</td>
<td>Quantity – 1. Part #55357-GTBKDB201120110. Include FPM monitor arm. For Computer Lab only.</td>
</tr>
<tr>
<td>Equipment rack</td>
<td>Middle Atlantic</td>
<td>SRSR-2-14</td>
<td>Secure to cabinet or desk.</td>
</tr>
<tr>
<td>USB transmitter</td>
<td>Extron</td>
<td>USB Extender Plus T</td>
<td>Provide quantity as required for system operation.</td>
</tr>
<tr>
<td>USB receiver</td>
<td>Extron</td>
<td>USB Extender Plus T</td>
<td>Provide quantity as required for system operation.</td>
</tr>
</tbody>
</table>

2.3 CABLES AND WIRES

A. Provide cables and wires that are continuous - without splices.
B. For CATEGORY-type UTP cabling (cables, termination apparatus and installation requirements), refer to section 271513.
C. Cable selection
   1. Refer to functional diagrams for signal type between equipment.
   2. Select a cable with the appropriate rating and configuration required by the applicable building code, electrical code, AHJ, and applicable codes and regulations governing the installation.
   3. For cables that will be installed in conduit within on-grade concrete, select a cable rated for underground construction.
   4. For cables that will be installed outdoors in underground conduit, aerial, and/or corrosive environments, select a cable rated for outdoor construction.
   5. For signal extenders, use extender the manufacturer’s recommended cable type and within the maximum cable run length to be used.
D. Unless otherwise called for in these specifications and drawings, the following cables are approved for the associated application or signal type. Ensure the chosen cable is appropriate for the signal type, available pathway capacity, and run length.

<table>
<thead>
<tr>
<th>Application</th>
<th>Non-Plenum Product</th>
<th>Plenum Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet</td>
<td>Refer to section 271513</td>
<td>Refer to Section 271513</td>
</tr>
<tr>
<td>HDBaseT</td>
<td>West Penn 4246F</td>
<td>West Penn 254246F</td>
</tr>
<tr>
<td></td>
<td>Belden AV6SHR</td>
<td>Belden AV6SHP</td>
</tr>
<tr>
<td></td>
<td>Extron XTP DTP 24</td>
<td>Extron XTP DTP 24P</td>
</tr>
<tr>
<td></td>
<td>Superior Essex 6H-246-xA</td>
<td>Superior Essex 6H-246-xB</td>
</tr>
<tr>
<td></td>
<td>Or equal by Liberty, Crestron</td>
<td>Or equal by Liberty, Crestron</td>
</tr>
<tr>
<td>Control cable</td>
<td>West Penn 77350</td>
<td>West Penn D25350</td>
</tr>
<tr>
<td></td>
<td>Liberty LLINX-U</td>
<td>Liberty LLINX-U-P</td>
</tr>
<tr>
<td></td>
<td>Or equal by Belden, Crestron</td>
<td>Or equal by Belden, Crestron</td>
</tr>
<tr>
<td>Microphone and line-level audio cable</td>
<td>West Penn 545</td>
<td>West Penn 25291B</td>
</tr>
<tr>
<td></td>
<td>Liberty 20-2C-SH-GRY</td>
<td>Liberty 20-2C-PSH-WHT</td>
</tr>
<tr>
<td></td>
<td>Or equal by Belden, Canare, Mogami</td>
<td>Or equal by Belden, Canare, Mogami</td>
</tr>
<tr>
<td>Program loudspeaker cable</td>
<td>West Penn 227</td>
<td>West Penn 25227B</td>
</tr>
<tr>
<td></td>
<td>Liberty 12-2C-GRY</td>
<td>Liberty 12-2C-P-BLK</td>
</tr>
<tr>
<td></td>
<td>Or equal by Belden, Canare</td>
<td>Or equal by Belden, Canare</td>
</tr>
<tr>
<td>Distributed loudspeaker speaker cable</td>
<td>West Penn 224</td>
<td>West Penn 25224B</td>
</tr>
<tr>
<td></td>
<td>Liberty 18-2C-GRY</td>
<td>Liberty 18-2C-P-BLK</td>
</tr>
<tr>
<td></td>
<td>Or equal by Belden, Gepco</td>
<td>Or equal by Belden, Gepco</td>
</tr>
<tr>
<td>ALS emitter</td>
<td>See Antenna cable (wireless microphone) – 50-ohm, below</td>
<td></td>
</tr>
<tr>
<td>Antenna cable (wireless microphone) – 50-Ohm</td>
<td>West Penn 813</td>
<td>West Penn 2598G8</td>
</tr>
<tr>
<td></td>
<td>Liberty RG8-CMR-BLK</td>
<td>Liberty RG8-CMP-BLK</td>
</tr>
<tr>
<td></td>
<td>Or equal by Belden</td>
<td>Or equal by Belden</td>
</tr>
<tr>
<td>Antenna cable (wireless microphone) – 75-Ohm</td>
<td>See CATV trunk and drop cables, below</td>
<td></td>
</tr>
<tr>
<td>Analog video coaxial cable, RG59-type</td>
<td>Extron 815</td>
<td>Extron 25815</td>
</tr>
<tr>
<td></td>
<td>Liberty RG59-CCTV-CM-BLK</td>
<td>Liberty RG59-CCTV-PL-BLK</td>
</tr>
<tr>
<td></td>
<td>Or equal by Belden, Canare, West Penn</td>
<td>Or equal by Belden, Canare, West Penn</td>
</tr>
</tbody>
</table>

2.4  HDBASET CABLE

A. Manufacturer, Or Equal

1. West Penn.

2.5  CONDUCTORS, POLYOLEFIN INSULATION, X-SPLINE, OVERALL BELDFOIL SHIELD, PVC JACKET

2.6  CUSTOM REMOTE CONTROL PANELS AND INTERFACE PLATES

A. For custom remote control panels and interface plates, use 1/8 inch (3mm) thick #6061 T6 aluminum, with a brushed, anodized, black finish (or as approved by the Architect via submittals).
2.7 EQUIPMENT PLATES

A. For equipment plates, utilize 1/32" to 1/16" thick by 1/4" high aluminum with a brushed anodized black finish.
B. Provide engraved lettering 1/8" to 3/16" high.

2.8 EQUIPMENT LABELS

A. For equipment labels, utilize white, self-laminating, machine-printable, permanent adhesive-backed tape, 3/8" to 1/2" high.
B. Provide text using black 12-point Helvetica, or a visually similar, san-serif typeface.
C. Manufacturer, or equal:
   1. Brady
   2. Brother
   3. DYMO XTL or Rhino
   4. Panduit
   5. Thomas and Betts

2.9 WIRE AND CABLE LABELS

A. Use either of the following label types for wire and cable labels:
   1. Tape – machine-printable, wrap-around, self-laminating, permanent adhesive-backed tape
   2. Machine-printable, shrink-wrapped labels
B. Provide labels with a white face stock (print area).
C. Size as needed per wire/cable size.
D. Provide labels that meet UL 969 requirements.
E. Manufacturer, or equal:
   1. Brady
   2. Brother
   3. DYMO XTL or Rhino
   4. Panduit
   a. #S100X075YAJ; self-laminating cable label, white face stock 1" wide, diameters 0.08"-0.16"
   b. #S100X125YAJ; self-laminating cable label, white face stock 1" wide, diameters 0.12"-0.28"
   c. #S100X150YAJ; self-laminating cable label, white face stock 1" wide, diameters 0.16"-0.32"
   d. #S100X225YAJ; self-laminating cable label, white face stock 1" wide, diameters 0.24"-0.48"

2.10 RACK BONDING

A. Refer to Section 270526 for approved bonding products.
PART 3 - EXECUTION

3.1 GENERAL
A. Comply with the Execution requirements in Section 270000.
B. Perform work in accordance with the standards and best practices defined by the InfoComm International coursework for Installation 1: System Fabrication and Installation 2: Setup and Verification.
C. Install products per manufacturers’ instructions.
D. Install panels, equipment, boxes, etc., plumb and square.
E. Seismic safety:
   1. Mount, anchor and/or brace permanently-installed equipment to the building structure using anchors, fastenings, supports, and methods approved by structural engineer with a safety load factor of at least 1.5. Provide installations that meet the most stringent of applicable codes and regulations to minimize potential damage to personnel and equipment from foreseeable seismic events.
   2. Brace hanging audiovisual and associated equipment both to minimize sway and to prevent detachment from the overhead structure in accordance with applicable codes.
   3. Firmly secure equipment in place unless requirements of portability dictate otherwise.

3.2 EXAMINATION
A. Prior to starting the work of this section, examine areas to receive system components and pathways to receive cabling to verify conditions are ready for work of this section and to verify conformance with manufacturer and specification tolerances.
   1. Verify that pathways, including conduit, junction boxes, cable trays, ceiling enclosures, etc., are in place prior to placing cables into pathways and as required by applicable codes.
   2. Verify that rough-in (including conduit, device boxes, floor boxes, and the like) is ready to receive wiring, cabling, devices, equipment, and the like prior to installing into the rough-in.
   3. Verify that electrical power service is ready and stable prior to connecting equipment.
   4. Check ceiling types, ceiling heights, and clearances above ceilings to ensure conditions are appropriate per manufacturer’s installation requirements.
B. Proceed with installation work only after unsatisfactory conditions are corrected.
3.3 INSTALLATION

A. Floor-standing equipment racks
   1. Completely assemble equipment racks. Include parts and accessories, such as electrical power distribution devices, cable dressing accessories, and blank and vent panels, required for a complete result.
   2. Anchoring/bracing: Anchor racks to the floor at four points per approved structural details using anchors and methods approved by a structural engineer. Seismically brace racks (e.g., using brackets, threaded rod with strut, etc.) as required, attached to the wall or structure above using appropriate anchors or fasteners.
   3. Tolerances: Verify dimensions to establish proper clearances. Install racks to attain clearance of at least 36” to the nearest piece of equipment from each enclosure’s front and back doors.
   4. Power strips: Install power strips on the back interior of the rack space on the left side as viewed from the back.
   5. Lighting: Install lights on the back interior of the rack space centered within the rack, magnetically attached or fastened to the frame, and situated to illuminate the back of the rack-mounted equipment and wiring.
   6. Refer to Section 27056 for grounding and bonding requirements.

B. Displays and mounts
   1. Wall-Mounted Displays: Install mounts using fasteners approved for the mounting substrate. For framed walls, firmly engage fasteners into backing or, if no backing is present, into framing studs.
   2. Ceiling-Mounted Displays: Install mounts to structure using fasteners and mounting accessories approved for the mount and mounting substrate. Install seismic restraints as appropriate for the installation location. Conceal cabling within mounting columns where feasible.
   3. Securely install displays onto mounts. Complete final connections (power, signal, control, etc.).
   4. Install accessories onto mounts or displays using approved attachment methods that guarantee the longevity of the installation. Accessories may be attached mechanically, if allowed by the display/mount manufacturer, or by using 3M TB3571/3572 hook and loop fastener tape or an approved equal.
   5. Dress cables; ensure they are maximally concealed yet serviceable.
   6. Adjust each display and mount to attain a true, square and level installed result.

C. Projection systems
   1. Projector Supports
      a. Anchor to structure using means approved by a structural engineer.
      b. Install lateral and/or transverse bracing to poles for seismic bracing as required.
      c. Securely install mounts onto poles using compatible adapting components.
   2. Projectors
      a. Securely install projectors to mounts.
      b. Fully assemble and install projectors, lenses, and mirrors such that the final condition will be no observable movement in the image induced by motor vibration or other mechanical operations.
      c. Install accessories onto mounts or projectors using approved attachment methods that guarantee the longevity of the installation. Accessories may be attached mechanically, if allowed by the projector/mount manufacturer, or by using 3M TB3571/3572 hook and loop fastener tape or an approved equal.
3. Align projection systems so projected images fill the viewing areas of the associated projection screens and exhibit no geometric distortion.
4. Only use physical and/or optical adjustments to correct geometric distortion.
5. Only use electronic or digital correction when called for in this document package.
6. Confirm that the total averaged light output from all projectors, in lumens, is at least 85% of that specified by the projector manufacturer.
7. Confirm that the light falloff from the center of the projected image to four corners, as measured at the projected image plane, does not exceed 50%.

D. Ceiling microphones
1. Review field conditions, and coordinate with the Architect or Engineer to resolve conflicts with other trades’ devices conflicting with microphone locations.
2. Route analog microphone cabling away from other cabling types. Where this cabling must cross other cabling types, install it at a 90° angle.
3. Install microphone preamplifiers, conversion devices, and other back boxes using safety wires attached to the building structure.
4. Prior to acceptance testing, confirm microphones do not produce audible buzz and/or noise.

E. Wireless microphone systems
1. Mount antennas external to equipment racks.
2. For wireless microphone systems using multiple antennas, space them per manufacturers’ recommendations.
3. Sequentially turn on each wireless system within RF range and allow it to complete its scanning procedure. Verify correct operation.

F. Antennas
1. Use antennas designed specifically for the frequency bands they will carry.
2. For antennas extended from the attached equipment, use cabling appropriate for the frequency and distance.
3. Use extender devices (preamplifiers) and distribution amplifiers per cabling lengths and manufacturers’ recommendations.
4. Install cabling per manufacturers’ bend radius guidelines.
5. Locate and orient antennas to ensure coverage throughout the room(s). Verify this by walk-testing systems.

G. Loudspeaker tap settings
1. Where loudspeaker tap wattages are specified in the design documents, set transformers per these. Otherwise, set taps per best practices.
2. Set taps such that the total wattage of a series of loudspeakers will not exceed 75 percent of the associated amplifier’s rated wattage.
3. Record tap settings per loudspeaker for inclusion on the as-built drawings.

H. Loudspeakers, acoustical tile ceiling mounted
1. Coordinate ceiling tile work (such as cutting holes) with the ceiling contractor.
2. Unless directed otherwise, center ceiling loudspeakers to ceiling tiles and evenly space loudspeakers.
3. Cut ceiling tiles to fit loudspeaker such that no gaps are visible after the loudspeaker cover/grille is installed.
4. Install ceiling loudspeakers with safety wires attached to the building structure per applicable codes and best practices.
5. Use tile rails and other support components to ensure loudspeakers do not sag.
6. Where manufacturer labels are visible on loudspeaker grills and are rotatable, align these consistently.
7. Replace ceiling tiles damaged during loudspeaker installation work.

I. Loudspeakers, gypsum ceiling mounted
   1. Coordinate ceiling work (such as cutting holes) with the framing contractor.
   2. Unless directed otherwise, align and evenly space loudspeakers.
   3. Cut wallboard to fit loudspeaker such that no gaps are visible after the loudspeaker cover/grille is installed.
   4. Install ceiling loudspeakers with safety wires attached to the building structure per applicable codes and best practices.
   5. Where manufacturer labels are visible on loudspeaker grills and are rotatable, align these consistently.

J. Cabling and wiring – at racks
   1. Do not use electrical tape for bonding, splicing, joining, or any other purpose.
   2. As a general practice, run power cables, control cables, and other cables with higher voltage levels on the left side of an equipment rack as viewed from the back; run other cables with lower voltage levels on the opposite side. Where wiring issues or wire routing facilities preclude this configuration, it is acceptable to deviate from the directions above, if separation is maintained between signal and electrical power cables.
   3. To reduce signal contamination, group cables per the signals being carried. Maintain appropriate distances between cable groups, especially between high-current (power; loudspeaker) and low-current (microphone) groups. Form separate groups for the following cables/signal types:
      a. Power
      b. Control
      c. Analog video
      d. Digital audio and video
      e. Analog microphone audio
      f. Analog line audio
      g. Loudspeaker audio
      h. Radio frequency
   4. Within racks, install wires and cables with service loops. Provide sufficient cable to allow each piece of equipment to be removed from the front of the rack for servicing.
   5. At boxes or points of termination, install wires and cables with service loops. Provide sufficient cable to allow each piece of equipment to be removed and laid flat on a surface for servicing.
   6. At slide-out equipment racks, dress cables to allow racks to be extended to the maximum length of the rack slides. For slide-out rotating racks, provide sufficient cable to allow full extension and rotation.
   7. For cables that interface with racks, cabinets, consoles, or equipment modules, use screw-type terminal blocks, terminal strips, or connectors. Telephone-style punch-down blocks (e.g., 110 blocks) are not acceptable.
   8. Do not bend any cable or wire tighter than the manufacturer’s minimum bend radius.
   9. Install wires and cables such that the cable exerts no strain on its termination.
   10. Label wires and cables, regardless of length, using a cable label with a unique number or letter per the instructions below under “Labeling”.
   11. Cable Shield Bonding: For cables with shields, connect them using approved connectors per an approved grounding topology.
   12. Encase umbilicals connecting moveable racks and cabinets to walls and other fixed locations in braided sleeving. Where racks and cabinets are installed in view of non-technical people, coordinate sleeving colors with the Architect.
K. Cabling and wiring – overhead distribution

1. Use cabling appropriate to loudspeaker impedance, cabling distance, and installation conditions (such as plenum versus non-plenum).
2. The use of electrical tape for bonding, splicing, joining, or any other purpose is prohibited.
3. Provide cable runs between termination points that are continuous, with sheath continuity. Splices are not permitted anywhere.
4. Place cables within designated pathways, such as cable tray, cable hangers, etc. Do not fasten cables to other building infrastructure (such as ducts, pipes, etc.), other systems (such as ceiling support wires, wall studs, etc.), or to the outside of conduits, cable trays, or other non-approved pathway systems.
5. Protect cables from physical interference and damage during installation and termination. Install cables with no kinks or twists.
6. Install HDBaseT cables within manufacturers’ length recommendations.
7. Comply with manufacturers’ limits for pulling tension.
8. Do not use cable-pulling compounds for indoor installations.
9. Install cables within manufacturers’ bend radius limits. If no minimum bend radius is given, then maintain a minimum bend radius of six times the cable diameter during and after installation.
10. Route cables under building infrastructure (such as ducts, pipes, conduits, etc.); do not route cables over building infrastructure. Install cables to provide accessibility for future service.
11. Place cables 6”, minimum, away from power sources to reduce interference from EMI.
12. Connectors: Use the following connectors:

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategory</th>
<th>Type</th>
<th>Acceptable Manufacturers</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio</td>
<td>Low-level</td>
<td>RCA / S/PDIF</td>
<td>Switchcraft</td>
<td>Pomona</td>
</tr>
<tr>
<td>Audio</td>
<td>Low-level</td>
<td>3.5mm TRS</td>
<td>Switchcraft</td>
<td>Neutrik Amphenol</td>
</tr>
<tr>
<td>Audio</td>
<td>Low-level</td>
<td>1/4” TS/TRS</td>
<td>Switchcraft</td>
<td>Neutrik Amphenol</td>
</tr>
<tr>
<td>Audio</td>
<td>Low-level</td>
<td>XLR</td>
<td>Switchcraft</td>
<td>Neutrik ITT Cannon</td>
</tr>
<tr>
<td>Audio</td>
<td>Low-level</td>
<td>Combo XLR/TRS</td>
<td>Neutrik</td>
<td>No substitutions</td>
</tr>
<tr>
<td>Audio</td>
<td>Low-level</td>
<td>TA-series (mini XLR)</td>
<td>Switchcraft</td>
<td>No substitutions</td>
</tr>
<tr>
<td>Audio</td>
<td>Low-level</td>
<td>Microdot</td>
<td>Switchcraft</td>
<td>Lemo</td>
</tr>
<tr>
<td>Audio</td>
<td>Microphone, no mute control</td>
<td>XLR-3</td>
<td>Switchcraft</td>
<td>Neutrik ITT Cannon</td>
</tr>
<tr>
<td>Audio</td>
<td>Microphone, with mute control</td>
<td>XLR-5</td>
<td>Switchcraft</td>
<td>Neutrik ITT Cannon</td>
</tr>
<tr>
<td>Audio</td>
<td>Microphone under table or desktop, no mute</td>
<td>R3F</td>
<td>Switchcraft</td>
<td>Neutrik ITT Cannon</td>
</tr>
<tr>
<td>Audio</td>
<td>Microphone under table or desktop, with mute</td>
<td>R5F</td>
<td>Microphone under table or desktop, no mute</td>
<td></td>
</tr>
<tr>
<td>Audio</td>
<td>Low or high-level</td>
<td>Phoenix</td>
<td>Phoenix Contact</td>
<td></td>
</tr>
<tr>
<td>Audio</td>
<td>High-level</td>
<td>Banana</td>
<td>Pomona GC Electronics</td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Subcategory</td>
<td>Type</td>
<td>Acceptable Manufacturers</td>
<td>Comments</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>------</td>
<td>--------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Audio</td>
<td>High-level</td>
<td>Speakon</td>
<td>Neutrik, Switchcraft</td>
<td></td>
</tr>
<tr>
<td>Video</td>
<td>50-ohm</td>
<td>BNC</td>
<td>Kings, AMP - TE Connectivity</td>
<td>Trompeter</td>
</tr>
<tr>
<td>Video</td>
<td></td>
<td>Triax</td>
<td>Trompeter</td>
<td></td>
</tr>
<tr>
<td>Video</td>
<td></td>
<td>HDMI bulkhead barrel</td>
<td>Switchcraft, Cliff, Neutrik, Harting</td>
<td></td>
</tr>
<tr>
<td>Video</td>
<td></td>
<td>HDMI cable</td>
<td>Extron, Crestron</td>
<td></td>
</tr>
<tr>
<td>Video</td>
<td></td>
<td>DisplayPort cable</td>
<td>Extron, Crestron</td>
<td></td>
</tr>
<tr>
<td>Video</td>
<td></td>
<td>Mini DisplayPort/ Thunderbolt cable</td>
<td>Extron, Crestron, Apple</td>
<td></td>
</tr>
<tr>
<td>Video</td>
<td>D-sub</td>
<td>HD-15 (&quot;VGA&quot;) cable</td>
<td>Extron, Crestron, Cables to Go</td>
<td></td>
</tr>
<tr>
<td>RF</td>
<td>75-ohm</td>
<td>BNC</td>
<td>Kings, AMP - TE Connectivity</td>
<td>Trompeter</td>
</tr>
<tr>
<td>RF</td>
<td></td>
<td>F-type</td>
<td>Belden, Amphenol, Liberty, Digicon</td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Subcategory</td>
<td>Type</td>
<td>Acceptable Manufacturers</td>
<td>Comments</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>-----------------------------</td>
<td>--------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>RF</td>
<td>UHF</td>
<td>Amphenol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>D-sub</td>
<td>DB-9, DB-25</td>
<td>Amphenol, TE Connectivity</td>
<td>Or as provided with equipment</td>
</tr>
<tr>
<td>Control</td>
<td>Phoenix</td>
<td>Phoenix Contact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Modular</td>
<td>4p4c plug</td>
<td>Molex, TE Connectivity</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Modular</td>
<td>8-contact</td>
<td>Ortronics, Panduit, Belden, Molex</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>USB cable</td>
<td>A, B, C types</td>
<td>Extron, Crestron, Hosa, Belkin</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Crimp</td>
<td>Fork lug</td>
<td>Molex, TE Connectivity, Phoenix Contact</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>etherCON</td>
<td>RJ45</td>
<td>Neutrik, ITT Cannon</td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td>FC</td>
<td>Molex, TE Connectivity</td>
<td>3M</td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td>opticalICON</td>
<td>Click-on duplex</td>
<td>Neutrik</td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td>LC</td>
<td>Molex, TE Connectivity</td>
<td>3M</td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td>LC Duplex</td>
<td>Molex, TE Connectivity</td>
<td>Conec</td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td>SC</td>
<td>Molex, TE Connectivity</td>
<td>3M</td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td>SC Duplex</td>
<td>Molex, TE Connectivity</td>
<td>3M</td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td>SMA</td>
<td>Industrial Fiberoptics, TE Connectivity, Phoenix Contact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td>ST</td>
<td>Molex, TE Connectivity</td>
<td>3M</td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td>TOSLINK</td>
<td>Tripp Lite</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

L. Terminations and Cords at Floor Boxes

1. Provide strain relief for cables. Use appropriate cable management products (such as hook and loop straps for UTP and STP cabling, and nylon cable ties for other cables) to group similar cable types.
2. Provide permanent labels on cables within 6” of terminations.
3. Provide permanent labels on receptacles within floor boxes to clearly identify terminations and services.
4. Encase umbilicals connecting moveable racks, cabinets, etc., to floor boxes in braided sleeving. Where racks and cabinets are installed in view of non-technical people, coordinate sleeving colors with the Architect.

M. Blank panels: Provide blank trim plates in floor, wall and furniture-mounted boxes at unused termination positions. Fill each module opening filled, either with a receptacle, a receptacle plate, or a module of the type the opening is intended to house.
N. Patch panels
   1. Assignments: Wire patch panels so that signal sources appear on the upper row of a row pair; and destinations appear on the lower row of a row pair. Submit variations from this approach per the requirements in Submittals.
   2. Designation strips: Utilize alphanumeric identifications and descriptive information on audio and video patch panel designation strips. Number the jack positions in each row sequentially from left to right. Letter the jack rows sequentially from top to bottom. Include the alphanumeric identification of each jack on the functional block drawings. Mount reproductions of these drawings in an appropriate location near the patch bays.

3.4 EDID MANAGEMENT

A. For each system, determine the maximum pixel resolution, frame rate, and color depth supported by all content displays, and designate this as the target resolution for the system. Omit digital signage displays from this process.
   1. Scalers: Configure video scalers as follows:
      a. Input: Emulate the EDID configuration of the native resolution of the connected display or projector for both analog and digital inputs.
      b. Output: Configure to match the native resolution of the display system and at the highest supported scan rate.

B. Determine the system’s maximum audio parameters – output channel count, LFE capabilities, etc.

C. Configure the system’s EDID management to ensure that these audio and video parameters are sent to source devices.

3.5 HDCP MANAGEMENT

A. Include HDCP support in all equipment that incorporates copy protection for the transport of copyrighted media.
   1. Installation requirements
      a. Equipment capable of passing HDCP included in this project must support the same HDCP version (i.e. HDCP 1.4 or HDCP 2.2).
   2. Exceptions
      a. HDCP may be defeated for educational institution projects per ‘fair use’ copyright terms.

3.6 NETWORK SECURITY

A. Leave no network-connected device operating with its factory-default password.

B. Obtain Owner defined password changes for all network-connected devices. Program these passwords into the devices.

C. Where available, enable two-factor authentication.

3.7 PROGRAMMING AND EQUIPMENT CONFIGURATION

A. General Programming
1. Install the most current version of manufacturers’ firmware on devices.

B. Audio Processor Programming
1. The following instructions apply to all systems including programmable audio processors and microphones.
2. Make equalization and other room tuning adjustments to obtain the flattest, and least colored result the system is capable of.
3. After tuning the system, perform other adjustments, such as dynamics, AEC, etc.

C. Control System and Button Controllers
1. Owner’s requirements
   a. Meet with the Owner and document their functional and user interface requirements (backgrounds, color scheme, screens, menus, functions, etc.).
   b. Develop programming and user interfaces based on the user requirements.
   c. Submit touch panel layouts and menu flow documentation to the Owner and Engineer per submittal schedule.
   d. Meet with the Owner and Engineer and present the control system programming and user interfaces. Obtain the Owner’s approval on these items.

2. Programming guidelines
   a. Create initial screens (splash screens) that use a version of the Owner’s logo, generated without visible scaling artifacts.
   b. Only use red for alarm indicators and other screen elements of special significance.
   c. Avoid use of technical terms, rather, use clear, everyday language. For example, instead of “System On”, use “Turn System On”; instead of “Power Down”, use “Turn Power Off”, etc.
   d. Ensure soft buttons are sized consistently and spaced evenly.
   e. Ensure spelling, punctuation, and grammar are 100% correct.
   f. Provide menus on both touch panels and control system web pages that appear and function consistently throughout the project.
   g. Ensure items with similar functions appear consistently in all menus.
   h. Provide soft button presses that display visual feedback, and if required by the Owner, audible feedback.
   i. Source selection shall be available at all times without powering on the projector and will display on the local monitor to allow previewing of material.
   j. Label button control as allowed by manufacturer. All buttons with programmed functions will be labeled. Buttons that have no function should be removed or blanked, if possible, and spare labels or blanks provided to Owner.

3. Tech menu: Provide a “tech” menu for each touch panel. Include in tech menus:
   a. Volume control for button audible feedback
   b. Screen brightness
   c. A means to change the tech screen password; obtain from the Owner’s Representative a default password for all touch panel tech menus
   d. Other technician-specific functions required for each system

4. Make IP control system devices (touch panels, controllers, processors, etc.) accessible and controllable via the network and via web access. For example, users and/or technicians shall be able to operate touch and pushbutton panel functions remotely. Coordinate with the Owner’s Representative to ensure a successful implementation of this requirement.
5. In AV-equipped rooms with an operable partition, program the AV system to use signals from the rooms' partition sensors to automate audiovisual system combine/divide functions.

D. Power control and sequencing

1. Whether explicitly listed in this specification or not, provide power control interfaces, e.g., remotely controllable PDUs, for equipment and devices that are not equipped with integrated power control. Provide power control interfaces that are fully compatible with the specified control system. Follow this directive for devices, such as audio power amplifiers, which would not be adversely affected by external power controls. Omit such power controls for devices, such as transmitters and receivers, that should not be externally power controlled.

2. Configure non-controlling items to power off or go into a standby/low power-consumption mode when systems are powered off. At minimum, program the AV system to power off the following types of devices when not in use:
   a. Audio processors
   b. Audio amplifiers
   c. Displays
   d. Projectors

3. Configure devices that detect connection to user devices to stay in standby/low power-consumption mode when audiovisual systems are turned off.
   a. Video switchers and processors

4. When turning systems on, use the following sequence for audio components.
   a. Turn on source devices.
   b. Turn on processing and routing devices.
   c. Turn on amplifiers.

5. When turning systems off, use the following sequence for audio components.
   a. Turn off amplifiers.
   b. Turn off processing and routing devices.
   c. Turn off source devices.

E. Network connection

1. Connect all network-connectable equipment and devices to the network. Program them to electronically issue notifications for preventative maintenance (e.g., replace a projector lamp).

2. Coordinate with the Owner’s Representative which devices are to provide notification (e.g., email notification) immediately at the time of a fault and which devices will provide notifications on a daily or weekly report.

3. Coordinate with the Owner’s Representative to obtain the default notification means (e.g., the email address for maintenance messages).

4. Ensure the Owner’s Representative can revise the maintenance email address via a simple method – using a single address for all networked AV devices. Document this procedure in the Operations Manual.

F. Equipment configuration:

1. Blu-ray disk players: Set color space to RGB.

2. Computer interfaces, signal extenders and transmitters with integral input switching: Program each device and related system components involved so that the analog audio input is active regardless of which video input is selected.
3.8 LABELING

A. Provide labeling identifiers that match closeout documentation (e.g., as-built drawings, O&M Manual, etc.).
B. Clean and degrease surfaces receiving nameplates and labels prior to affixing labels.
C. When creating labels for user-facing equipment and cables, use colored labels where possible. Example uses are floor boxes, table boxes, cameras, displays, and user-facing cables. Use color coding to relate labels to related components, i.e., match the text and color on each user-facing cable, its corresponding button on the button panel, and its corresponding input on the display. Example: HDMI 2 cable has a yellow label printed with “HDMI 2”, the button panel at the table box has a yellow “HDMI 2” label and the input on the display has a yellow label printed with “HDMI 2”.
D. Interface plate designation
   1. Provide wall-mounted interface plates with clearly engraved alphanumeric identification of input type (e.g., “MIC-1”, “LINE IN”, “SPEAKER”, “VIDEO”, etc.) and corresponding patch field designation.
E. Equipment enclosures
   1. Install the label on the top of the rack or cabinet, centered horizontally.
   2. Example: line 1: “AV-01”, line 2: “Audiovisual Devices”.
F. Equipment
   1. Rack-mounted equipment: Install labels in visible locations on equipment and devices on the front and back of the equipment.
   2. Field equipment: Install labels in visible locations on miscellaneous field equipment and devices.
G. Wireless transmitters and receivers
   1. Label wireless transmitters and receivers so users can clearly identify a given transmitter associated with its receiver.
   2. Use an identifier, such as a room number, that associates each transmitter with a given room or system.
   3. Example: RM.230–MIC.3–RCVR.1
H. Wire and cable
   1. Comply with the Owner’s labeling requirements. If the Owner does not have labeling requirements, conform with InfoComm F501.01.
   2. Provide labels with machine-generated text; hand-written labels will not be accepted.
   3. Provide labels with black text 1/8” high or #12 font size.
   4. Generate a unique identifier for each cable and wire using the system defined in the InfoComm F501.01 standard. Include “primary level” data elements (per F501.01); “secondary level” (per F501.01) data elements are optional.
   5. Install labels on both ends of cables no more than 4” from the edge of the cable. Install labels such that they are visible by a technician from a normal stance.
I. Batteries
   1. Label batteries with the month and year they were installed.
   2. Example: “Installed April 2017”

3.9 FIELD QUALITY CONTROL
A. Initial tests and measurements: Prior to final adjustment and scheduling acceptance testing, perform initial tests and measurements. At minimum, include the following initial tests and measurements:

1. Adjust, balance, and align equipment for optimum quality and to meet manufacturers’ published specifications.
2. Perform the test procedure provided at the end of this specification and return the completed form no less than one week prior to the initial punch walk.
3. For rack-mounted equipment with user-accessible controls, install 1/8” diameter vinyl "map dots" as indicators for nominal operating positions of rotary, slider, and other accessible controls. Provide multiple dots, adequately distinguished, for controls having more than one nominal operating position.

B. Test twisted-pair cabling per Section 270811.

C. Digital video cabling: Follow the following procedure to test each provided digital video cable.

1. HDMI: Quantum Data 780, or equal
2. DVI/SDI/HD-SDI: Quantum Data 882D, or equal
3. DisplayPort: Quantum Data 882E-DP, or equal
4. Test Procedure:
   a. Test each cable.
   b. Replace all cables that fail.

D. Audio system:

1. Loudspeaker line impedance: Measure the impedance at 63 Hz, 250 Hz, and 1 kHz and the resistance of each loudspeaker line leaving the sound equipment rack with the line disconnected from its normal driving source. For lines to full range distributed loudspeaker systems, measure impedance at 1 kHz.
2. Hum and noise level:
   a. Measure the hum and noise levels of the overall system for each microphone input channel and line level input channel.
   b. Adjust gain controls for optimum signal to noise ratio so that full amplifier output is achieved with 0 dBm at a line level input.
   c. Terminate line level inputs with resistors of 150 and 600 ohms, respectively, for these measurements.
   d. Disconnect the loudspeaker lines and terminate the power amplifier outputs with power resistors for these measurements. Use load resistors within 5% of the nominal load impedance of the amplifier under test. Use resistors with power ratings equal to or greater than the power rating of the amplifiers.
3. System frequency response:
   a. Measure audio system frequency response for the AV systems described in Part 1. Adjust systems to provide specified performance.
4. Uniformity of coverage:
   a. Using a calibrated testing device, measure octave bands using a pink noise test signal played through the loudspeaker system(s).
5. System power output and signal level adjustment:
   a. Measure the electrical distortion of the overall system for each line level input channel.
   b. Adjust gain control as for the tests specified herein.
c. Apply a 1 kHz sine wave signal from a test signal generator having less than 0.5% total harmonic distortion at the input tested, at a level required to produce full amplifier output. Note that a pad with 150-ohm output impedance is required for driving the microphone level input in accordance with the EIA standard.

d. Use a distortion analyzer to measure the output level and total harmonic distortion of the audio equipment. In the absence of a distortion analyzer, a high input-impedance measuring device such as a DMM may be used to measure the output level.

6. Loudspeaker polarity

a. Perform loudspeaker line polarity checks using a polarity tester or use DC source at one end of each line and a voltmeter at the other end. Confirm that loudspeaker lines are correctly polarized with respect to color coding.

b. Confirm loudspeaker polarity using a polarity tester.

7. Freedom from parasitic oscillation and radio frequency pickup:

a. With systems set up for each mode of operation specified in the Part 1, confirm that systems are free from spurious oscillation and radio frequency pickup, in the absence of audio input signal and when the system is driven to full output at 100 Hz.

b. Confirm these tests audibly and by using an oscilloscope having at least 5 MHZ bandwidth.

c. Apply a slow sine wave sweep from 50 Hz to 5 kHz at a level of 6 dB below rated power amplifier output to each system. Listen carefully for buzzes, rattles and objectionable distortion.

d. Correct causes of these defects unless the cause is clearly from other than the sound amplification system's equipment and installation, in which case bring the cause to the attention of the Owner and Architect.

8. Audio test signal paths: Verify operation from source inputs through system components to signal destinations.
E. Analog composite video system:
   1. Signal to noise: Operate the system using an RS-170A test signal. Measure and
document output noise levels using a composite video distortion analyzer.
   2. Differential gain: Using an RS-170A step test signal and a waveform monitor, measure
chrominance, luminance, and normal synchronizing and blanking signals. Measure
variations in chroma subcarrier amplitude at 10%, 50%, and 90% luminance.
   3. Differential phase: Operate the system as indicated above and measure chroma
subcarrier phase variations at 10%, 50%, and 90% luminance.

F. Projection systems:
   1. For each projection system, measure light intensity at the screen’s center and four
corners. Take corner measurements 5% of the image area width and height in from
image edges.
   2. Use a properly calibrated foot-candle (or lux) meter with cosine correction for the above
measurements.

G. Control systems:
   1. Verify all operational functions at each fixed control interface position.
   2. Verify all operational functions of the control system and interfaced devices.

3.10 CLEANING, PROTECTION AND REPAIR

A. Comply with the cleaning requirements of Section 270000.
B. During the installation and up to the date of final acceptance, protect finished and unfinished
work against damage and loss. In the event of such damage or loss, replace or repair such
damaged work.

3.11 SUBCONTRACTOR MANAGEMENT

A. Continuously supervise subcontractors during the installation; intermittent supervision is not
acceptable.

3.12 SYSTEM ACCEPTANCE TESTS

A. Perform system acceptance tests after completion of initial system checkout and after
submitting the Initial Testing and Tuning Report.
B. Prior to setting up a demonstration and/or punch walk with the Engineer, ensure that the
System/Systems are complete, operational, and fully functioning, and that pre-functional and
functional testing have been completed. Fees for any additional punch walks resulting from
incomplete and/or non-functioning Systems may be assessed.
C. System acceptance tests consist of the following:
   1. Take a physical inventory of equipment on site and compare it to equipment lists in the
contract documents.
   2. Demonstrate the operation of system equipment.
   3. Perform both subjective and objective tests to determine compliance with the
specifications. Provide test equipment specified for these tests.
   4. Provide final, "as built" drawings, run sheets, manuals, and other required documents, as
detailed in Part 1.
   5. Provide complete testing reports generated by subsystems that provide self-testing.
6. Perform power on/off cycles to ensure these take place with no audible and only minimally visible artifacts, pops, etc.

D. Initial Testing and Tuning Report
   1. Perform the following tests for each system unless otherwise noted in Part 1.
   2. Use additional pages as necessary to allow complete comments.
   3. Where blanks are provided in the checklist below, observe the associated value in parenthesis.
<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
<th>Result</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Record equipment that was specified but is not present. Provide a reason why this equipment is not present.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Confirm no sharp or jagged surfaces are accessible to users and technicians.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Confirm that each active device’s external temperature, measured using a non-contact thermometer, is within manufacturer’s guidelines.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Perform and log cable inspection. Confirm each cable is labeled, dressed, included in a bundle with cables with like signals, not under stress, is serviceable, is correctly strain-relieved, is not bent beyond manufacturer’s recommended bend radius, does not have tie wraps tensioned excessively or used inappropriately. Confirm labels are positioned and oriented consistently and are legible and unambiguous.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Demonstrate that the full inventory is new equipment, in full compliance with the specification, or as modified by approved submission. Record test results as pass/fail, and list exceptions.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Confirm rack elevation and single-line drawings, cable and other labels and engravings are an accurate model of the furnished system, and comply with latest revised specifications. Record test results as pass/fail.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Confirm switcher inputs and outputs are labeled (wherever possible), so that users can easily make manual routes quickly without having to refer to the system drawings.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Confirm amplifier channels are properly labeled, so technicians can make quick adjustments without having to refer to the system drawings.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Confirm rack mounted equipment is labeled and that the labels match those on the drawings (equipment symbols and/or description), control system, field plates, patch panels, and any labels associated with the system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Confirm modular terminations are solid in their connectors.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Confirm each coax cable respects the manufacturer’s minimum bend radius or at least 5x the cable’s diameter.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Record ambient noise, A-weighted, slow.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test</td>
<td>Description</td>
<td>Result</td>
<td>Comment</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>13</td>
<td>Confirm power amplifiers are working within rated load. Record the impedance (and at what frequency) of each loudspeaker line on each power amplifier at 63, 250, and 1,000 Hz.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Using appropriate test signals, have the sound system produce a nominal operating level of (65) dB SPL for conference speech, (60) dB SPL for program material, “A” weighted at all listeners’ ears ± (2) dB (“Uniformity of Coverage”) (or at least (15) dB above the ambient noise, A-weighted, whichever is greater), with the control system volume control indicating “normal” or default setting. Record results for each channel and source.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Confirm the system is capable of producing an additional (15) dB above this level (80) dB SPL for each audio source, with less than 0.5% THD (Total Harmonic Distortion) plus noise. Measure THD plus noise when source is at (15) dB above nominal operating level at each “destination”, for all sources selected.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Confirm the system develops a noise level that is electrically (55) dB below the normal operating level for all audio sources. “Noise” refers to the aggregate of hum, electrostatic noise, RF interference, etc. Measure and record Signal to Noise (“signal” measured electrically at nominal operating level at each destination, for all sources selected.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Confirm program loudspeakers are connected in the same polarity, and speech reinforcement systems are polarized such that a positive acoustic pressure on a microphone results in a positive acoustic pressure at the loudspeaker (“Polarity Test”).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Confirm the system produces no more than a (1) dB variance in program source levels when each program source is playing audio from a calibrated medium (CD, test signal generator, etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Confirm there is no audible vibration caused by improper mechanical installation. Use a continuous sweep signal at headroom level (from an audio test signal generator or test CD.) Provide a pass/ fail result and document which device fails and the frequency of these artifacts. (“Buzzes and Rattles Test”).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Confirm speech reinforcement systems are stable, with no ringing nor feedback.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test</td>
<td>Description</td>
<td>Result</td>
<td>Comment</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>21</td>
<td>For audio conference systems, adjust microphone input gain to demonstrate that a &quot;standard talker&quot; (60 dB SPL at 1 m), positioned at each talker position in the room, produces a 0 dB level at the input of the mixer bus of the audio conference DSP device. If there is local voice reinforcement (&quot;mix-minus&quot;), AGC and ALC may need to be restricted when performing this test. <strong>Record test results as pass/fail. Record level across analog telephone line, if one is used. Inspect DSP mixer telephone line levels, both transmit and receive, when normal speech is encountered in the room.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>For conferencing mode, at the <em>(65)</em> dB SPL listening level, confirm full duplex operation, with no reports of echo or &quot;speech trails&quot; as detected from the far end.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Confirm equalizers, whether hardware or virtual, are adjusted for best intelligibility, and in accordance with any preferred acoustic level response curves. <strong>Record the “house curve” before equalization, as well as after the equalizers have been tuned, with and without microphone input filters. If requested by the Consultant, produce this documentation for systems without equalizers, as this test may apply to the preamp filter settings in cases where intelligibility can be improved.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>If required, confirm system intelligibility, with a RSTI (Rapid Speech Transmission Index) greater than 0.85.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>For wireless microphone systems, with all wireless microphones turned on, confirm that throughout the specified operating area for the transmitter, there are no dropouts, intermodulation interactions between wireless systems, nor RF-caused artifacts.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>If required, for composite video sources, connect a test generator at each input and confirm 1 volt peak-to-peak to each destination ± 10% (or 1dB). <strong>Record results at each destination using NTSC/PAL bars, peak white, and five-step multiburst (0.5, 1.0, 2.0, 3.0, 3.58, and 4.2 MHz).</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>For NTSC sources, confirm optimum brightness, contrast, and color in displays using a SMPTE source with PLUGE display.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Where several displays are visible in the same space, confirm picture tonal consistency across all of them. For composite video signals, use NTSC color bars with PLUGE signal to all. For digital video signals use a colorimeter and test color signal software to confirm consistent images</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test</td>
<td>Description</td>
<td>Result</td>
<td>Comment</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>29</td>
<td>Confirm projectors are focused, centered, and evenly illuminated. <em>If requested, confirm using a calibrated light meter that the brightest measurement locations are no more than +10% above average, and the dimmest locations no less than –5% below average measurement. If requested, document that geometric distortion is within 2% tolerance. Take actual measurements if necessary (top, bottom, left, right dimensions of white portion of screen) and photograph if necessary.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Confirm that the system displays with stability, and with no scaling-related visual artifacts when switching between, at a minimum, the resolutions specified in 1.04 D. Record test results.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Where HDMI, DVI, or DisplayPort signals are included in the system, confirm that an acceptable signal is being displayed on the monitor from each source position. Use the Alt Pixel test image (pixel-on, pixel-off) for each resolution included in the design intent: 1,920x1,200@60, 1,920x1,080@60, 1,280x720@60, as required. Inspect each, leaving the signal on for three minutes. Confirm that no artifacts are visible. For systems including 4k displays, test also at 3,840 x 2,160 and 4,096 x 2,160. Note: If the signal is going to a codec, disable HDCP. If the signal is going to a display, enable HDCP unless specified otherwise in Part 1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Using a signal generator, confirm scaler and display/projector configurations by successfully passing video at the resolutions defined in 1.04 D.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Confirm HDCP is maintained from sources to destinations except as excluded above. Confirm EDID is managed correctly and that devices output at resolutions supported by the system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Confirm the control system controls all of the required equipment as specified. Confirm system performs with stability and in sync with the equipment being controlled without the need to reset any item of equipment. Confirm that user interface requirements dictated in Part 3 of the audiovisual specifications have been met.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test</td>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Confirm system is serviceable: all devices must be easily removable for repair by one person; all cables must be dressed neatly and be provided with adequate service looks, must be bundled in forms (refer to “Sound System Engineering”, Davis and Davis, 1987 and “Audio Systems Design and Installation”, Giddings, 1990) having no excessive pressure on cables at termination points and connectors, and each cable number must agree with the shop drawings and cabling run list.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Confirm switches and receptacles are logically and permanently labeled.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Confirm nomenclature for consistency: drawings, touch screen, wall plates, floor boxes, patch panels, equipment, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Confirm patch cables have cable numbers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Where cameras are included in system, confirm each operates correctly and provides correct image quality.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Confirm camera presets are programmed as specified by the user. In the absence of Owner direction, create and document presets that are logical for the room’s layout.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Confirm TV reception from all included sources (OTA, CATV, etc.) and that all channel presets are accurate.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Confirm and document the IP configuration information provided by the Owner is loaded into the equipment, including IP and MAC addresses, Dante device names, subnet masks, gateways, time server, gatekeeper, etc. Confirm that all network functions specified by the customer function properly on the customer's LAN.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Confirm all web-based system control and monitoring features, and other IP system functionality (time servers, system-generated e-mail, etc.) are completely functional.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Confirm that display devices have On-Screen Displays/Menus disabled. If the customer has directed otherwise, document from which person this direction came.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Confirm that video projectors have blue screens or other images or colors displayed in the absence of an input signal disabled. If the customer has directed otherwise, document from which person this direction came.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test</td>
<td>Description</td>
<td>Result</td>
<td>Comment</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td>46</td>
<td>Log test conference calls (audio and video). Include in the log start time, line used, number called, status of connection (completed/failed, etc.) who was spoken with at the far end, success of full duplex, success of auto-disconnect, dB SPL in the room. Note static, jitter/packet loss, or any other artifacts, distortion, etc. Note if auto-disconnect functions as specified.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Using a full-screen white test signal, confirm no direct view display nor projector has more defective pixels than specified in Part 1. Note number and location of lost pixels, if any. Provide photos of defects. Include room numbers and any other distinguishing information in photo file names.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Check for excessive vibration on VC camera(s) at full telephoto position.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Provide video recordings of all non-conformances and anomalies.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Confirm all visible devices are installed square and plumb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Confirm no dust, grease, scratches, or any other signs of handling are visible on any devices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Confirm assistive listening systems work throughout intended listening areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>Confirm closed captioning is functional on all displays</td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Confirm control system user interfaces provide a means to enable and disable display of closed captions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

E. If further adjustment is required, or defective equipment must be repaired or replaced, tests may be suspended or continued at the option of the Owner or Owner’s representative.

1. If the need for further adjustments becomes evident during the demonstration and testing, continue work until the installation operates properly. Included in the continued work, changes to or installation of resistive pads, adjustment of loudspeaker aiming, adjustment of system processing, programming changes to the control system, convergence and/or alignment of the video projector, if these adjustments are required.

2. If acceptance of the system is delayed because of defective equipment or because the equipment does not fulfill this specification, reimburse the Owner for time and expenses for these tests during extensions of the acceptance testing period.

3.13 OWNER TRAINING

A. Provide a minimum of twenty four hours of training on the audiovisual systems specified herein at the project site (or other location designated by the Owner) by a qualified instructor (equipment manufacturer as needed) covering operation and maintenance of the systems.

B. Provide on-site AV support to the Owner during first beneficial use or special event.
3.14 MAINTENANCE AND EXTENDED SERVICE

A. Warranty Maintenance

1. On a quarterly basis during the warranty period, execute a service visit to check and adjust equipment and systems such that they maintain the original performance. Coordinate visits directly with the Owner.

2. Pre-emptive maintenance minimum requirements:
   a. Clean filters, vents, and lenses, and dust the equipment.
   b. Verify projector images fill screens appropriately and images are focused.
   c. Test and verify that all system controls operate as labelled and that the controlled devices respond accordingly.
   d. Document and photograph any conditions that may affect the continued function and long-term operation of the audiovisual system and report to owner.
   e. Document and report projector lamp life to the Owner and replace lamps as directed.

B. Provide cost for additional service levels beyond the warranty period (as defined in this section) as follows:
   1. One year, two-year, and three-year service with quarterly pre-emptive maintenance calls and same-day issue response
   2. One year, two-year, and three-year service with quarterly pre-emptive maintenance calls and 24-hour issue response
   3. One year, two-year, and three-year service with quarterly pre-emptive maintenance calls and 48-hour issue response

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This section includes general administrative and procedural requirements for Division 28 and is intended to supplement, not supersede, the requirements specified in Division 1.

B. The requirements described herein include the following:
   1. References
   2. Definitions
   3. System Description and Existing Conditions
   4. Submittals
   5. Quality Assurance
   6. Permits and Inspections
   7. Coordination
   8. Project Management and Coordination Services
   9. Product Delivery, Storage, and Handling
   10. Warranty
   11. Maintenance

C. Products furnished and installed under another Section:
   1. 120V power
   2. Conduit, junction boxes, device boxes (essentially rough-in)
   3. Door hardware
   4. Network Connections

D. Related Sections:
   1. General and Supplementary Conditions: General provisions of the Prime Contract and Divisions 00 and 01 apply to Division 27.
   2. Consult other Sections, determine the extent and character of related work, and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable installation.
   3. Section 26 05 33, “Raceway and Boxes for Electrical Systems”
   4. Section 27 05 28, “Communications Building Pathways”
   5. Section 28 05 13, “Security System Cabling”
   7. Section 28 08 00, “Security System Acceptance Testing”
   8. Section 28 13 00, “Access Control and Alarm Monitoring System”
   9. Section 28 16 00, “Intrusion Detection System”
   10. Section 28 23 00, “Video Surveillance System”
   11. Section 14 20 00, “Elevators”
   12. Division 27
   13. Earthwork: Include trenching, backfilling, boring and soil compaction as required for the installation of underground conduit, in-grade pull boxes, vaults, and bollard foundations.
   14. Selective Demolition: Nondestructive removal of materials and equipment for reuse or salvage as indicated. Also dismantling electrical materials and equipment made obsolete by these installations.
15. Concrete Work: Include forming, steel bar reinforcing, cast-in-place concrete, finishing and grouting as required for underground conduit encasement, pedestal foundations, and curbs. [Also includes saw-cutting of existing slabs and grouting of conduits in saw-cut.]

16. Miscellaneous Metal Work: Include fittings, brackets, backing, supports, rods, welding and pipe as required for support and bracing of raceways, equipment enclosures, cameras, and similar devices.

17. Miscellaneous Lumber and Framing Work: Include wood grounds, nailers, blocking, fasteners, and anchorage for support of security materials and equipment. Refer to Division 6, Rough Carpentry.

18. Moisture Protection and Smoke Barrier Penetrations: Include membrane clamps, sheet metal flashing, counter flashing, caulking and sealant as required for waterproofing of conduit penetrations and sealing penetrations in or through fire walls, floors, ceiling slabs and foundation walls. Tape and make vapor tight penetrations through vapor barriers at slabs on grade.

19. Division 8 Locking Hardware: Include interface to electronic hardware and door controllers on security related doors.

20. Access Panels and Doors: Required in walls, ceilings, and floors to provide access to security devices and equipment.

21. Painting: Include surface preparation, priming and finish coating as required for security cabinets, exposed conduit, pull and junction boxes, and devices where indicated as field painted in this Division. Refer to Division 9, Painting.

22. Elevators: Include interface to elevator floor and hall call on security related elevators.

1.2 REFERENCES

A. General

1. Codes, standards, and industry manuals/guidelines listed by reference, including revisions by issuing authority, form a part of this specification section to extent indicated. Consider such codes and/or standards a part of this Specification as though fully repeated herein.

2. Standards listed are identified by issuing authority, authority abbreviation, designation number, title or other designation established by issuing authority. Standards subsequently referenced herein are referred to by issuing authority abbreviation and standard designation.

3. Reference to codes, standards, specifications and recommendations of technical societies, trade organizations and governmental agencies shall mean that latest edition of such publications adopted and published prior to submittal of the bid unless otherwise specifically stated

B. Codes: Perform Work executed under this Section in accordance with applicable requirements of the latest edition of governing codes, rules and regulations including but not limited to the following minimum standards, whether statutory or not:

1. California Code of Regulations (CCR):
   a. Title 8, “Industrial Relations”
      1) Chapter 3.22, “California Occupational Safety and Health Regulations (CAL/OSHA)”
   b. Title 24, “California Building Standards Code”
      2) Part 2, Volumes 1 and 2, “California Building Code” (CBC)
      3) Part 3, “California Electrical Code” (CEC)
      4) Part 11, “California Green Building Standards Code” (CALGeen)”
2. National Fire Protection Agency (NFPA)
   a. NFPA 70, “National Electrical Code” (NEC)
   b. NFPA 75, “Protection Of Information Technology Equipment”

   b. Part 27, “Miscellaneous Wireless Communications Services”  
   c. Part 68, “Connection of Terminal Equipment to the Telephone Network”

4. International Code Council  

5. Other applicable national, state, and local binding building and fire codes

C. Standards: Perform Work and furnish materials and equipment in accordance with the latest editions of the following standards as applicable:

1. Underwriter’s Laboratories (UL): Applicable listing and ratings.  
   a. UL 294, “Access Control System Units”  
   b. UL 1076, “Proprietary Burglar Alarm Units and Systems”  
   c. UL 2044, “Commercial Closed-Circuit Television Equipment”

1.3 DEFINITIONS

A. The Definitions of Division 1 apply to the sections of Division 28.

B. In addition to those Definitions of Division 1, the following list of terms as used in this specification defined as follows:

1. “ACAMS”: Access Control & Alarm Monitoring System  
2. “As directed”: As directed or instructed by Owner, or their authorized representative  
3. “Cabling”: A combination of cables, wire, cords, and connecting hardware [e.g., cables, conductor terminations, connectors, outlets, patch panels, blocks, and labeling]  
4. “Connect”: To install required patch cords, equipment cords, crossconnect wire, etc. to complete an electrical or optical circuit  
5. “Engineer”: TEECOM  
6. “Furnish”: To purchase, procure, acquire, and deliver complete with related accessories  
7. “Contractor”: To be determined  
8. “IDS”: intrusion detection system  
9. “Install”: To set in place, join, unite, fasten, link, attach, set up or otherwise connect together and test before turning over to Owner, parts, items, or equipment supplied by Contractor or others. Complete installation and make ready for regular operation  
10. “Owner”: Contra Costa College  
11. “Provide”: furnish and install  
12. “Security System”: the ACAMS, IDS, VSS, and Intercom systems collectively and integrated  
14. “VAC”: volts alternating current  
15. “VDC”: volts direct current  
16. “VSS”: video surveillance system
17. “VMS”: visitor management system

1.4 SYSTEM DESCRIPTION

A. Overview
1. Contra Costa College is constructing a 3-story multi-level building.
2. Security at the new facility consists of access control and alarm monitoring (ACAMS), video surveillance (VSS), intrusion detection (IDS), and intercom systems. The ACAMS will automate opening and closing the buildings, control access through designated doors, and will restrict after-hours access to authorized cardholders, and the IDS will monitor specific spaces for intrusion.
3. The new system will connect to Owner’s exiting head end located at the district office over the Owner’s LAN/WAN.
4. The System includes integration to the Fire/Life Safety system to disconnect power to magnetic door holders and automatically close doors after hours.
5. The System includes elevator security and integration between the electronic security system and elevator controller.
6. Refer to individual sections for detailed description of systems.

B. Custom Device Requirements
1. General: Provide a high level of coordination services to ensure the proper installation and functioning of the security system. Coordinate the installation of the security system with other trades. This may include: review of other trade’s shop drawings, attendance at meetings, providing samples for mockup, and preparation & distribution of written documentation.

C. Base Bid Work
1. Access Control and Alarm Monitoring System (ACAMS)
   a. The Owner requires an access control system to automate opening and closing of the building, restrict access afterhours by cardholder privileges, and monitor specific spaces for intrusion.
   b. The ACAMS consists of card readers, control panels, power supplies, workstations, alarm monitoring devices, and interfaces to other security equipment.
   c. Refer to Section 28 13 00 for detailed description of system.
2. Intrusion Detection System (IDS)
   a. The IDS consists of keypads, control panels, duress buttons, alarm monitoring devices, and interfaces to other security equipment.
   b. The IDS will communicate with a remote, third-party central station for alarm monitoring and contact Police Services during day-time operation and dispatch of the local Police Department after hours.
   c. Refer to Section 28 16 00 for detailed description of system.
3. Video Surveillance System (VSS)
   a. The Owner requires a video surveillance to provide a photographic record of access control transactions and alarm events, some real-time monitoring of the facility, and integration with the access control and alarm monitoring system.
   b. The VSS consists of a combination of analog and IP cameras, power supplies, IP encoders, and network video recorders.
   c. Refer to Section 28 23 00 for detailed description of system.
4. The System includes integration with the Elevator conveying system to provide the following:
   a. Individual floor and/or hall call access control

5. The System includes integration with the Fire/Life-Safety system to provide the following:
   a. Automatically release locks upon fire alarm activation for doors within the path of egress
   b. Disconnect power to magnetic door holders to automatically close doors after business hours

1.5 SUBMITTALS

A. General: Refer to Division 01 for Submittal requirements applicable to this Section.

B. Required submittals include the following:
   1. Written detailed project description
   2. Project schedule as referenced in this section
   3. Product data sheets – clearly indicate by arrows or brackets precisely what is being submitted on and those optional accessories which are included and those which are excluded
   4. Estimated delivery lead times for products
   5. Voltage drop calculations demonstrating less than ten percent voltage loss to individual security devices
   6. Battery calculations showing backup support of security equipment and locks (except egress hardware with local power supplies) for 25 lock activations or 4 hours, whichever is greater

C. Complete submittals are comprised of shop drawings and product data sheets as detailed below and related sections (covering specific security systems). Incomplete or partial submittals will be rejected.

D. Shop Drawings
   1. Obtain written approval from the Engineer for the shop-drawings submittal prior to the release of materials and equipment purchase order and prior to installation.
   2. Quantity and Media: Submit shop-drawings as described in Division 1.
   3. Shop drawings shall document Contractor’s intent to execute the work and shall include the following:
      a. Title sheet and index
      b. Floor plans showing device locations, cable routing, and pathways
      c. System block diagrams
      d. Point-to-point wiring diagrams
      e. Specific wiring details and device mounting/installation details
      f. Schedules:
         1) Building/floor
         2) Unique device name/number
         3) Security controller/location
         4) Interfaces, interlocks
         5) IP address
         6) Master/substation intercom calling locations
4. Upon award of contract, request CAD release forms from TEECOM so that electronic files may be released for Contractor’s use. TEECOM will release floor plans with devices; TEECOM will not release installation details and block diagrams (Contractor shall develop their own diagrams and details for the shop drawings submittal package).

E. Format: Furnish submittal data in electronic copy including table of contents with each section bookmarked by specification section listing materials.

F. Label each submittal with the specification section number and provide a cover letter or stamp stating that the submittal has been thoroughly reviewed by Contractor and complies with the requirements of the contract documents. Failure to comply with this requirement will constitute grounds for rejection of the submittal.

G. Resubmittals: Provide a cover letter with the resubmittal that lists the action taken and revisions made to each product submittal in response to submittal review comments. Failure to include this cover letter will constitute rejection of the resubmittal package and no review will occur.

H. Drawings
   1. Prepare shop and as-built drawings using software compatible with AutoCAD and/or Revit per project standard.
   2. Drawing requirements:
      a. Sheet size: match the project’s contract drawings size and use the project’s title block
      b. Text size: minimum 3/32 inches high when plotted at full size
      c. Symbology: match the project’s contract drawings symbols
      d. Backgrounds: screen background information to allow pertinent drawing information to stand out.
      e. Line Weights: Use appropriate line weights for devices, raceways, and text to stand out against background information.
      f. Floor Plans: 1/8-inch scale floor and site plans showing the locations of devices and cable routing paths with cable types and quantity called out.

I. Contractor Qualifications: Submit the following for review and comment at the beginning of the project.
   1. Resumes of the project manager, general foreman, and lead technician(s) indicating role, years of experience, product certifications and training, listing of similar projects the individual performed the role proposed for this project along with client contact information for each.
   2. Certification letters from manufacturers of major system components stating Contractor is an authorized reseller, installer, and extended warranty provider for the specified security systems.

J. Samples
   1. Submit samples as required for proper coordination and installation of custom mounted equipment. Examples of samples that may be required include:
      a. Screen shots showing graphical floor plan maps indicating:
         1) Active functional icons
         2) Secure areas/zones
      b. Camera field of views
1.6 QUALITY ASSURANCE

A. General
1. Provide new and unused materials, equipment, and parts comprising the units specified herein of current manufacturer and of highest grade.
2. Only use products and applications listed in this Division on the project.

B. Bid Discrepancies
1. In the event of discrepancies within the contract documents, notify Engineer within 5 days prior to the bid opening to allow the issuance of an addendum.
2. If time does not permit notification or clarification of discrepancies prior to the bid opening, the following applies: The drawings govern in matters of quantity, and the specifications govern in matters of quality. In the event of conflict within the drawings involving quantities, or within the specifications involving quantities, or within the specifications involving quality, the greater quantity and higher quality apply. Note such discrepancies and clarify in the bid. We will make no additional allowances because of errors, ambiguities, or omissions, which reasonably should have been discovered during the preparation of the bid.

C. Substitutions
1. Conform to the substitutions requirements and procedures outlined in Division 01
2. Only one substitution for each product specified will be considered.
3. Where products are noted as “or equal”, a product of equivalent design, construction, and performance is considered. Include in the product data submittal: catalog cuts, product information, and pertinent test data required to substantiate that the product is in fact equivalent to that specified.
4. Only one substitution allowed for each product specified. Do not provide substituted material, processes, or equipment without written authorization from Engineer. Assumptions on the acceptability of a proposed substitution, prior to acceptance by Engineer, are at the sole risk of Contractor.
5. The burden of proof rest with Contractor that the substituted product is equivalent or better than the specified product. When Engineer accepts a substitution in writing, it is with the understanding that Contractor guarantees the substituted product, component, article, or material to be equivalent to the one specified and dimensioned to fit within the construction according to contract documents. Approved substitutions do not relieve Contractor of responsibilities for the proper execution of the Work, or from provisions of the Specifications.
6. Manufacturers’ names and model numbers used in conjunction with materials, processes or equipment included in the contract documents are used to establish standards of quality, utility and appearance. Materials, processes or equipment that, in the opinion of Engineer, are equivalent in quality, utility and appearance will be approved as substitutions to that specified when “or equal” follows the manufacturers’ names or model number(s).
7. Whenever material, process or equipment is specified in accordance with a Federal specification, an ASTM standard, an ANSI specification, UL rating or other association standard, present an affidavit from the manufacturer certifying that the product complies with the standard specification. When requested by Engineer, submit support test data to substantiate compliance at no additional cost.
8. Pay expenses, without additional charge to Owner, in connection with substitution materials, processes and equipment, including the effect of substitution on self, Subcontractor’s or other Contractor’s work.

D. Electronic Control Systems Contractor Qualifications
1. A current, active, and valid C7 or C10 license registered with the Contractors State License Board (CSLB)
2. Minimum five years of experience in installation and service of access control, video surveillance, and intrusion detection systems
3. Minimum five completed projects similar to scope and cost
4. Evidence of technicians qualified for the work in the form of current manufacturer’s training certification

E. Materials
1. Provide new materials and equipment without defects.
2. Provide only specified products and equipment, or products and equipment that have been approved in writing.

F. Regulatory Requirements
1. Work and materials to conform to the latest rules of National Board of Fire Underwriters wherever such standards have been established and to the regulations of the State Fire Marshal, OSHA and the codes of the governing local municipalities. Perform work under these specifications confirming to the most stringent of the applicable codes.
2. Provide the quality identified within these specifications and drawings when codes, standards, regulations, etc. allow Work of lesser quality or extent. The contract documents address the minimum requirements for construction.

G. Drawings
1. Layout: Follow the general layout shown on the Drawings except where other work may conflict with the Drawings.
2. Accuracy: The Drawings show a diagrammatic representation of the system within the constraints of the symbology applied.
3. Detail: The drawings do not fully represent the entire installation for the Security System. Drawings indicate the layout and location of control console(s) components, as well as location of security devices, i.e. card readers, door locks and contacts, and duress stations. The drawings do not show conduits, wire and cabling between every system component, equipment, or device.
4. Complete the details necessary for point-to-point design. This allows Contractor to achieve desired results applying their own procedures and methods. Submit shop drawings for review prior to installation.

H. Role of Engineer
1. During the construction phase of the project, Engineer will work with Contractor to provide interpretation and clarification of project contract documents, process and reply to relevant Requests for Information (RFI), and act as an interface between Contractor and Owner.
2. Owner has retained Engineer’s services to observe the work for general compliance with the contract documents.
3. In summary, Engineer will perform the following specific services during the design phase:
   a. Review product submittals and shop drawings for general compliance with the contract drawings and specifications.
   b. Review changes as they arise and confirm that the proposed solutions maintain the intended functionality of the system.
   c. Interpret field problems for Owner and translate into understandable language.
   d. Review the testing procedures to confirm compliance with industry-accepted practices.
1.7 PERMITS AND INSPECTIONS

A. Obtain and pay for permits and inspections required for the work.

B. Furnish materials and workmanship for this work in conformance with applicable legal and code requirements.

C. Perform tests required herein, or as may be reasonably required to demonstrate conformance with the Specifications or with the requirements of legal authority having jurisdiction.

D. Obtain review from compliance officials responsible for enforcement of applicable codes and regulations to establish that the work is in compliance with requirements of reference codes indicated herein.

1.8 PROJECT MANAGEMENT AND COORDINATION SERVICES

A. Provide a project manager for the duration of the project to coordinate the security system work with other trades. Coordination services, procedures and documentation responsibility include at a minimum, the items listed in this section.

B. Review of Shop Drawings prepared by Other Subcontractors:
   1. Obtain copies of shop drawings for equipment and systems provided by others that require connections or interface with the security system work. Thoroughly review those shop drawings to confirm compliance with the interface requirements.
   2. Document discrepancies or deviations:
      a. Prepare memo summarizing the discrepancy.
      b. Submit a copy of the specific shop drawing, indicating via cloud, the discrepancy.
   3. Prepare and maintain a shop drawing review log indicating the following information:
      a. Shop drawing number and brief description of the system/material
      b. Date of your review
      c. Name of the individual performing the review
      d. Indication if follow-up coordination is required

C. Scheduling: Prepare work schedules for each floor indicating the following information:
   1. Submittals
   2. Cable Installation
   3. SEC Build Out
   4. Device Installation
   5. Programming
   6. Testing
   7. Training
   8. Other tasks included under the alternate work section of these specifications

D. Job Conditions
   1. Protection: Keep conduits, junction boxes, outlet boxes and other openings closed to prevent entry of foreign matter. Cover equipment, devices, and apparatus to protect them against dirt, paint, water, chemical or mechanical damage, before and during construction period. Prior to final acceptance, restore to original condition fixture, apparatus or equipment damaged including restoration of damaged factory applied painted finishes. Protect bright finished surfaces and similar items until in service. No rust or damage will be permitted.
2. Supervision: Personally, or through an authorized and competent representative, supervise the work from beginning to completion and, within reason, keep the same foreman and workmen on the project throughout the project duration.

E. Weekly Status Reports: Prepare weekly status reports throughout the entire course of the project containing the following information:
   1. Current / up-to-date 2-week look ahead schedule
   2. Progress during prior week
   3. Work expected to be completed during the upcoming week
   4. Delivery dates for equipment
   5. Coordination status for each device requiring coordination with other subcontractors
   6. Summary of the information owed to Contractor, who is responsible for providing the information, and due date for the information

F. Weekly Meetings: Conduct or attend weekly coordination meetings with the electrical and other specialty subcontractors to coordinate the installation of the security systems.

1.9 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Delivery
   1. Do not deliver security system components to the site until protected storage space is available.
   2. Replace equipment damaged during shipping and return to manufacturer at no cost to Owner.

B. Storage
   1. Store materials in a clean, dry, ventilated space free from temperature extremes. Storage outdoors covered by rainproof material (for example, a tarp) is not acceptable.
   2. Maintain factory wrapping or provide a heavy canvas/plastic cover to protect units from dirt, water, construction debris, and traffic.
   3. Provide heat where required to prevent condensation or temperature related damage.

C. Handling
   1. Handle in accordance with manufacturer’s written instructions.
   2. Prevent internal component damage, breakage, denting and scoring. Do not install damaged equipment. Replace damaged equipment and return equipment to manufacturer.

1.10 WARRANTY

A. Provide the Security System as described in this specification with a one-year parts and service warranty at no additional cost to Owner.

B. Include in the warranty package, at a minimum, the following:
   1. Software support agreement for the ACAMS and VSS
   2. Software upgrades and patches
   3. Labor to install software upgrades and patches necessary to maintain the latest version
   4. Emergency maintenance service on regular working hour basis
   5. Service by factory trained and employed service representatives of system manufacturer
C. Maintain regular service facilities and provide a qualified technician familiar with this work at the site within four hours of receipt of a notice of malfunction including weekends and holidays. Provide material, devices equipment and personnel necessary for repairs. Install approved temporary, alternate equipment if required by Owner, complete and operational within 24 hours after notification of a malfunction, at no additional cost.

D. Conduct warranty repairs and service at the job site unless in violation of manufacturer’s warranty; in the latter event, provide substitute systems, equipment and/or devices, acceptable to Owner, for the duration of such off-site repairs. Transport warranty substitute and/or test systems, equipment, devices, material, parts and personnel to and from the job site at no additional cost.

E. Warranty period shall commence upon written final acceptance by Owner or Owner’s designated representative.

1.11 MAINTENANCE

A. Extra Materials
   1. Deliver extra materials to a secured location determined by Owner.
   2. Provide a complete bill of materials listing quantities, part numbers, and descriptions for each device for Owner to sign indicating receipt of equipment.
   3. Provide new and unused spare parts in their original packing materials upon delivery.

B. Maintenance Service
   1. For the first year of service, conduct quarterly system performance review meetings to review system operation problems and/or defects that occurred during the preceding 3 months. During these performance review meetings, perform the following:
      a. Visual checks and operational tests of the central processor, local processors, monitors, keyboards, system printers, peripheral equipment, security equipment and devices, power supplies, and electrical and mechanical controls.
      b. Clean system equipment, including interior and exterior surfaces.
      c. Perform diagnostics on equipment.
      d. Check and calibrate each device.
      e. Run system software and correct diagnosed problems.
      f. Resolve previous outstanding problems.
   2. Provide software and firmware updates issued free of charge by the manufacturer.

PART 2 - PRODUCTS

2.1 GENERAL

A. Material and equipment specified herein have been selected as the basis of acceptable quality and performance and have been coordinated to function as components of the included systems. Where a particular material, device, equipment or system is specified directly, the current manufacturer’s specification for same is a part of these specifications, as if completely elaborated herein.

B. Remove manufacturer identification marks from visible equipment. Provide materials permanently labeled with the manufacturer’s name, model and serial number.
C. Use standard, regularly manufactured, materials and equipment for this and/or other similar systems, and not custom designed especially for this project. Provide systems and components thoroughly tested and proven in actual use. Provide subsystems of one manufacturer.

2.2 EQUIPMENT ENCLOSURES AND JUNCTION ENCLOSURES

A. Application: For indoor use to house panels and equipment, and to house terminations, relays, and other components local to controlled doors and other field devices

B. Type: NEMA type 1 enclosure

C. Description:
   1. Solid steel enclosure with solid, continuous-hinged door
   2. Finish: ANSI 61 gray polyester powder paint finish inside and out
   3. Lockable / equipped with a lock kit (lock kits shall be keyed alike with other security enclosures throughout the project)
   4. Perforated back panel within enclosure (for mounting control boards, relays, terminal strips, etc.)
   5. One tamper switch per enclosure
   6. One 5” electric fan with a screen at the port per enclosure that houses electrically-powered devices/equipment

D. Size:
   1. For use as Security Equipment Enclosure: 36"L x 24"W x 6"D minimum
   2. For use as Security Junction Enclosure: 12"L x 12"W x 6"D minimum

E. Manufacturer, or equal:
   1. Eaton Cooper B-Line
      a. #36246-1PP; 36"L x 24"W x 6"D enclosure with back panel and lock kit
      b. #12126-1PP; 12"L x 12"W x 6"D enclosure with back panel and lock kit
   2. Hoffman
      a. #A36N24M; 36"L x 24"W x 6"D enclosure
      b. #A36N24MPP back panel for 36" x 24” enclosure
      c. #A12N126; 12"L x 12"W x 6"D enclosure
      d. #A12N12PP; back panel for 12" x 12” enclosure
      e. # A612AR; lock kit
   3. Wiegmann
   4. SquareD

2.3 SLOTTED WIRING DUCT

A. For indoor use inside equipment enclosures to manage/mind wiring.

B. Description:
   1. Type: Lead-free PVC with narrow finger design
   2. Color: Light gray
2.4 WIREWAYS

A. For indoor use with equipment enclosures to manage and route wiring and cabling.

B. Type: NEMA type 1 screw cover ‘gutter’ wireway and accessories

C. Description:
   1. Wireways shall have open top assembly and closure plates/end caps (to secure end of wireway sections).
   2. Finish: ANSI 61 gray polyester powder paint finish inside and out
   3. Size: 4" x 4", minimum

D. Manufacturer, or equal:
   1. Eaton Cooper B-Line #4448-G-NK; lay-in painted wireway without knockouts
   2. Hoffman #F44T148GP lay-in painted wireway without knockouts

2.5 INTERFACE RELAYS

A. Application: lock power switching and interfacing with other high-voltage powered equipment, i.e. gates, high-voltage locks, etc. (not for use at the output contacts on the access controllers since their rating is not adequate)

B. Type: Standard industry control, plug-in type with LED indicator lights to indicate when the relay is energized.

C. Contacts: Rated for 10 amps at 120VAC.

D. Coil Operating Voltage: as required, with 24VDC as first choice

E. Features:
   1. Color-coded test button
   2. Mechanical flag
   3. Snap-on label
   4. Pilot light
   5. 2mm test jacks
   6. Dual contact markings
   7. Snap-on number and letter markers
   8. Solid bus-bar socket construction

F. Relay bases shall be mountable on standard mounting rails

G. Manufacturer, or equal:
   1. Turck
   2. Idec
2.6 TAMPER RESISTANT HARDWARE

A. Tamperproof hardware shall be used in locations below 10’ exposed to the public.
B. Hardware exposed in public spaces shall be pinned-allen type.
C. Hardware used in specialty metal surfaces shall have a similar finish color.

2.7 WIRE CONNECTORS

A. Wire connectors shall be heat activated, gel filled.
B. Twist and solder/taped or wire nut connections are not acceptable.
C. Manufacturer, or equal:
   1. Dolphin
   2. 3M Terminals
   3. Fastenal Sealed Crimp and Solder connector

PART 3 - EXECUTION

3.1 EXAMINATION

A. Conditions: Verify existing conditions, which have been previously provided under other sections, are acceptable for product installation in accordance with manufacturer's instructions.
B. Pathways: Verify that pathways and supporting devices, which have been previously provided under other sections, are properly installed, and that temporary supports and devices have been removed.
C. Field Measurements: Verify dimensions of pathways, including length of pathways. For example, “True Tape” the conduits to verify cable distances.

3.2 FIELD QUALITY CONTROL

A. Staffing: Provide a qualified foreman who is in charge of the work and who is present at the job site at times work is being performed. Perform the work using skilled technicians under the direction of the foreman. Supervise the work force executing the work. Perform the installation within the restraints of the construction schedule. Do not change the supervisor during the project without prior written approval from Owner.
B. Inspection: Perform inspection after installation. Keep areas of work accessible and notify code authorities, or designated inspectors, of work completion released for inspection. Document completion, and inspection as required.

3.3 INSTALLATION

A. Perform this work in accordance with acknowledged industry and professional standards and practices and the procedures specified herein.
B. Provide a complete, operating system. Include devices specified including basic components and accessories, interconnecting wiring and other equipment and installation devices necessary for a complete system as specified.

C. System Password Management:
   1. Change default passwords.
   2. Create a base administrator account for Owner’s use/login.
   3. Install the latest security patches (for the operating system and each individual piece of equipment).
   4. Disable unused communication ports or protocols.
   5. Perform quarterly software security patch updates for the client during the warranty period.
   6. Contractor to turn over all source media including installation discs, manuals, drives, dongles, and licensing keys and codes.

D. Manufacturer's Instructions:
   1. Comply with manufacturer's product data, including product technical bulletins, product catalog installation instructions, and product carton instructions for installation.
   2. Maintain jobsite file of Material Safety Data Sheets (MSDS) for each product delivered to jobsite.

E. Boxes, Panels, and Enclosures
   1. Install boxes, panels, and enclosures square and plumb.
   2. Set flush-mounted units with the face of the cover, bezel, or escutcheon in the same plane as the surrounding finished surface.
   3. Mount boxes, panels, and trim so that there are no gaps, cracks, or obvious lines between the trim and the adjacent finished surface; ready them to receive final finish, as applicable.
   4. Install insulating terminations in signal circuit boxes, panels, wireways, or enclosures.

F. Painting
   1. Custom paint devices as indicated on the drawings.

3.4 REPAIR/RESTORATION

A. Replace or repair work completed by others that you deface or destroy, and at no cost to Owner.

B. Punch List:
   1. Inspect installed work and develop a punch list for items needing correction.
   2. Submit punch list to Engineer for review prior to performing punch walk with Engineer.

C. Re-Installation:
   1. Make changes to the system such that defects in workmanship are correct and cables and the associated termination hardware passes the minimum test requirements.
   2. Repair defects prior to system acceptance.

D. Painting: Repaint surfaces altered during installation of the security system to match previous conditions.
3.5 CLEANING

A. Remove temporary coverings and protection of adjacent work areas. Remove unused products, debris, spills, or other excess materials. Remove installation equipment.

B. Leave finished work and adjacent surfaces in neat, clean condition with no evidence of damage.

C. Repair or replace damaged installed products.

D. Legally dispose of debris in an environmentally friendly manner.

E. Clean installed products in accordance with manufacturer's instructions prior to Owner's acceptance.

END OF SECTION
SECTION 280413 - COMMON SUBMITTAL REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows.
   Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER’S AND GENERAL CONTRACTOR’S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect’s staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:

   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.

   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.

   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect’s notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.

1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.

   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition

   1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering
   1. Number submittals as described below to assist tracking.
   2. Number each submittal in the format nnnnnn-nn.
      a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
      b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
      c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
      d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
      e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 28 05 13 SECURITY SYSTEM CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. General: Furnish engineering, labor, materials, apparatus, tools, equipment, transportation, temporary construction and special or occasional services as required to make a complete working security system installation, as described in these specifications.

B. Section Includes: Cables and wires for security systems

C. Related Sections:
   1. Consult other sections; determine the extent and character of related work and properly coordinate work executed under this section with that specified elsewhere to produce a complete and operable system.
   2. Section 28 00 00, "Basic Security Requirements"
   3. Section 28 05 53, "Security System Labeling"
   4. Section 26 05 33, "Raceway and Boxes for Electrical Systems"
   5. Section 27 05 28, "Communications Building Pathways"
   6. Section 27 15 13, "Communications Horizontal Twisted Pair Cabling"

1.2 REFERENCES

A. Comply with the Reference requirements of section 28 00 00.

B. In additional to those codes, standards, etc., listed in section 28 00 00, products and work shall comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. NFPA 262, “Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces"
   2. ANSI/UL 1666, “Test for Flame Propagation Height of Electrical and Optical-Fiber Cable Installed Vertically in Shafts”
   3. ANSI/UL 1581, “Reference Standard for Electrical Wires, Cables and Flexible Cords”

1.3 SUBMITTALS

A. Submittal Requirements at Start of Construction:
   1. Product Data: Submit product information, including manufacturer, part number, description, use/application, jacket rating, outside diameter, etc.

B. Submittal Requirements at Closeout:
   1. Include wire and cable types in As-Built Drawings
   2. Include wire and cable information in O&M Manuals
1.4 SCOPE OF WORK

A. General:
   1. Provide engineering, labor, materials, apparatus, tools, equipment, transportation, temporary construction and special or occasional services as required to make a complete working security system installation as described in these specifications.

B. Cables for Security System
   1. Provide wires and cables sized to allow for voltage drop of 12VDC and 24VDC power service from power supplies in equipment rooms to field devices.
   2. Provide cables effectively shielded for video signal cable within the same conduit to mitigate interference or signal noise.
   3. Provide plenum rated jacket (type CL2P, CL3P, or CMP) on cables installed indoors where required.
   4. Provide PVC or PE jacket, flooded cables to prevent water intrusion where installed outdoors, underground, and/or within slab-on-grade. Provide transition of outdoor/underground cables to indoor cables when entering a building.
   5. Provide surge protection when cables enter buildings from outdoors where required by CEC.

C. Cable Supports and Pathways for Security System Cabling
   1. Provide dedicated cable support for security cables when not within primary pathways (such as cable tray). Coordinate work with Division 27 – particularly for use of pathways/cable support.

PART 2 - PRODUCTS

2.1 WIRE AND CABLE

A. General
   1. Provide required wire and cable sized to allow for voltage drop on long runs and effectively shielded as required to allow the routing of 12 & 24V power and video signal cable in the same conduit without interference or signal noise.
   2. Cable installed outdoors or in underground conduit must contain a PVC or Polyethylene jacket to prevent water intrusion and compliant with the TIA-455-82B water infiltration test.
   3. Cables installed indoors to contain a plenum rated jacket (type CMP).
   4. Application: Indoor use, for ACAMS, VSS, Security Communications System, and IDS
   5. Type: multi-conductor or paired, unshielded and shielded

B. Manufacturers, or equal:
   1. West Penn

C. Access Control & Alarm Monitoring System
   1. Plenum Jacketed Cable
      a. #18/2 AWG unshielded: West Penn #25224B, door contact cable
      b. #18/4 AWG unshielded: West Penn #25244B, REX and alarm device cable
      c. #18/6 AWG shielded (overall): West Penn #253186B, card reader cable
      d. #16/2 AWG unshielded: West Penn #25225B, lock power cable
2. Water Blocked Cable
   a. #18/2 AWG unshielded with Aquaseal tape: West Penn #AQC224, door contact cable
   b. #18/4 AWG unshielded with Aquaseal tape: West Penn #AQC244, REX and alarm device cable
   c. #18/6 AWG shielded (overall) with Aquaseal tape: West Penn #AQC3186, card reader cable
   d. #16/2 AWG unshielded with Aquaseal tape: West Penn #AQC225, lock power cable
   e. #14/2 AWG unshielded with Aquaseal tape: West Penn #AQC226, lock power cable from local power booster to exit device

D. Intrusion Detection System
   1. Plenum Jacketed Cable
      a. #22/2 AWG unshielded: West Penn #25221B, door contact cable
      b. #22/4 AWG unshielded: West Penn #25241B, keypad and alarm device cable
      c. #18/2 AWG unshielded: West Penn #25224B, control panel power cable

E. Video Surveillance System
   1. Cabling for IP cameras provided by Telecommunications contractor. Refer to Section 27 15 13 – Communications Horizontal Twisted Pair Cabling.
   2. Provide minimum RG-59/U CCTV video coaxial cable between analog cameras and the monitoring equipment, with the following features:
      a. 95% percent copper braid
      b. Foam dielectric
      c. Solid copper core
      d. 75 ohm characteristic impedance
      e. Plenum jacket
   3. Plenum Jacketed Cable
      a. #RG-59 coaxial: West Penn #25815, analog camera video cable
      b. #18/2 AWG unshielded: West Penn #25224B, power cable
      c. #22/4 AWG 2 pair individually shielded (overall): West Penn #D420, RS-422 communications cable for analog PTZ cameras
   4. Water Blocked Cable
      a. #RG-59/U coaxial with Aquaseal tape: West Penn #AQC815, analog camera video cable
      b. #18/2 AWG unshielded with Aquaseal tape: West Penn #AQC224, power cable
      c. #22/4 AWG 2 pair individually shielded (overall) with Aquaseal tape: West Penn #AQC430, RS-422 communications cable for analog PTZ cameras

2.2 MISCELLANEOUS COMPONENTS

A. Cable Ties
   1. General
      a. Provide Velco-style cable ties on security cabling within telecommunications spaces and covered wireways.
b. Dress and bind cabling with cable ties every 24” minimum.
c. Width: 0.75 inches
d. Color: Black

2. Manufacturer:
   a. Panduit #HLS-15-R-0 Black, 15 feet roll, cut to length
   b. Or Equal

B. Compression Seal BNC (Bayonet Neill Concelman) Connectors

1. General
   a. Suitable for use on RG-59 coaxial cable for CCTV systems.
   b. Compression seal connection
   c. Capable of accepting cable with outside diameters between 0.195 - 0.245 inches. Twist-on or crimp-on style connectors are not permitted.

2. Manufacturer:
   a. GEM Electronics #302-10CSTP compression seal BNC connector
   b. Or Equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Horizontal Cable Installation and Routing

1. Install cables and wires continuously (splices will not be permitted without written approval from the Engineer) for the entire length of run between connections and/or terminations.
2. Place and suspend cables within designated pathways, such as cable hangers, cable tray, etc. Do not fasten or attach cables (such as with cable ties) to other building infrastructure (such as ducts, pipes, conduits, etc.), other systems (such as ceiling support wires, wall studs, etc.), or to the outside of conduits, cable trays, or other non-approved pathway systems.
3. Place and suspend cables during installation and termination in a manner to protect them from physical interference or damage. Place cables with no kinks, twists, or impact damage to the sheath. Replace cables damaged during installation or termination at no additional cost.
4. Route cables at 90-degree angles, allowing for bending radius, along corridors for ease of access.
5. Route cables under building infrastructure (such as ducts, pipes, conduits, etc.) so the installation results in easy accessibility to the cables in the future.
6. Do not exceed manufacturer's limits for pulling tension.
7. Do not use cable-pulling compounds for indoor installations.
8. Dress and secure cables without stress and/or deformation. Dress and bind cabling with cable ties every 24” minimum. Within telecommunications spaces and covered wireways, provide Velcro-style cable ties on security cabling.
9. Install shielded wiring or route in separate raceways as recommended by the manufacturer's current requirements.
10. Place cables a minimum of 6” away from power sources to reduce interference from EMI.
11. Do not run signal wire and cable in parallel to power (120VAC).
12. When connecting to screw-type barrier blocks, terminate wires with insulated crimp-type spade lugs. Size lugs properly to assure high electrical integrity, i.e., low resistance connections.

13. Follow manufacturers recommended guidelines for installation.

14. When exiting the primary pathway (such as cable tray) to the device, exit via the top of the pathway. Secure the cables to the pathway using an approved cable tie.

15. When routing cables vertically in conduit for continuous distances greater than 30 feet, secure cables as the cables exit the vertical pathways. Secure cables using screw-flange nylon cable ties or similar approved ties. Provide symmetrical clamping devices with split, circular, or other wire conforming, nonmetallic bushings for coaxial cables.

16. Within telecom rooms, route and dress cables on the overhead cable support and, when routing vertically, fasten the cables onto wall-mounted vertical cable support every 24 inches on-center using cable ties.

B. Cable Support

1. Coordinate cable support work with sections 27 05 28 and 27 05 36 for indoor pathways such as cable hangers.

2. Above ceilings, support cables at intervals no greater than 5 feet.

3. Anchor cable support system/components to structure.

4. Vertical Support on floor space, not in riser system
   a. Route cable from below suspended ceiling devices to above ceiling when possible.
   b. When routing cable in fire-rated wall assemblies, provide conduit and firestopping.
   c. When routing cable on concrete tilt up style walls from below ceiling devices to above ceiling, provide conduit – either surface or recessed (depending on wall construction).
   d. For cable routed vertically from devices with no suspended ceiling, provide conduit stub from device junction box to 14 feet, minimum, above finish floor.

5. Vertical Support in riser system
   a. In vertical riser systems, route cable within conduit.
   b. Terminate conduit at each stacked closet in a lockable junction box. Size junction box as required per conduit size and quantity – 12" x 10" x 8", minimum.
   c. Support cables within the junction box at every other floor or approximately every 24 feet utilizing cable ties equipped with eyelets designed to accept screws for fastening or approved equivalent method.
   d. Label cables in accordance with section 28 05 53, “Security System Labeling”.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. General: Furnish engineering, labor, materials, apparatus, tools, equipment, transportation, temporary construction and special or occasional services as required to make a complete working security system installation, as described in these specifications.

B. Section Includes:
   1. Labeling of wire, cable, security devices, enclosures, and raceways.

C. Related Sections:
   1. Consult other Sections, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable system.
   2. Section 28 00 00, "Basic Security Requirements" includes general project requirements, submittal formats, warranty, and installation requirements.

1.2 SUBMITTALS

A. Product Data: Submit the following:
   1. Product information for components specified herein.
   2. List of equipment (wire, cable, devices, enclosures, and raceways) and the corresponding text for the label.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Engraved, plastic laminated nameplates, signs, and instruction plates. Engrave stock melamine plastic laminate 1/16-inch minimum thickness for signs up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger sizes. Use white letters for engraved nameplates and punch for mechanical fasteners.

2.2 WIRE AND CABLE LABELS

A. General
   1. Self-laminating adhesive laser labels.
   3. Cable size: 0.16 – 0.32” OD
   4. Color: white with black lettering
B. Manufacturer, or equal:
   1. Panduit #R100X125V1T, #R100X150V1T, and R100X225V1T wire marking labels (This is not in our current spec. I added because it's in the referenced spec. Please delete if we don't want it in our spec.)
   2. Brady #WML-211-295 and #WML-311-292 wire marking labels
   3. Or Equal

2.3 DEVICE LABELS

A. Self-laminating, type on tape, adhesive labels. Use Helvetica 12 pt text

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Requirements
   1. Label the security system components. The components include, but are not limited to, the following:
      a. Equipment Enclosures
      b. Conduits
      c. Security Devices
      d. Batteries
      e. Wires and Cables
      f. Equipment Racks
      g. Terminal Blocks
      h. Relays
      i. Patch panels, and the termination positions within the patch panels.
   2. Labels shall coincide with device IDs used on the record drawings.
   3. Degrease and clean surfaces to receive nameplates and labels.
   4. Install nameplates parallel to equipment lines. Secure nameplates to equipment fronts using machine screws.

B. Equipment Cabinets
   1. Label SEC enclosures associated with the security system with a nameplate.
   2. Mount label on exterior of door, centered horizontally, and positioned one-third of the door height vertically from the top.
       Line 2: “Security Equipment Cabinet” [1/4-inch-high letters]

C. Conduits
   1. Write the destination for every conduit entering a junction box, SEC, and CEC enclosure, or wireway using a black permanent ink marker next to the conduit inside the box.
   2. Example: “To SEC-01”

D. Security Devices
   1. Label devices associated with the security system with a permanent machine generated, laminated, label. Use 12-point Helvetica text with a clear background. Use white or black lettering depending upon the color of the device.
2. Label each device in a concealed location with the system point number and address.

E. Batteries
1. Label power supply batteries with the month and year they were installed.
2. Example: “April 2020”

F. Wire and Cable
1. Identify wire and cable clearly with permanent machine-generated labels wrapped about the full circumference within 1 inch of each connection.
2. Indicate the cable ID designated on the associated field or shop drawings or run sheet, as applies.
3. Assign wire or cable designations consistently throughout a given system; i.e., each wire or cable to carry the same labeled designation over its entire run, regardless of intermediate terminations.
4. Provide labels where wire and cable first enter and exit from conduit, junction or distribution boxes; locate labels within 6 inches of the point of exit.
5. Positional labels so they are clearly visible without the need to remove wire management or other obstructions.
6. Label cables at both ends of a run and within pull and junction boxes using machine generated wrap-around labels.

3.2 CABLE LABEL FORMAT

A. Text: Helvetica font, 12 point (minimum size, unless otherwise specifically stated)

B. From Panel to Field Device
1. Line 1: Device Type and Device Number
2. Line 2: Panel ID – Port Number
3. Example: CR 001
   PANEL 2 – CR5
4. Standard Device Types
   a. CR = Card Reader
   b. K = Camera
   c. ET = Entry Telephone
   d. R = Relay Output
   e. A = Alarm Point
5. Standard Port Numbers
   a. CR = Reader
   b. M = Monitored Input
   c. R = Relay Output

C. From Door Junction Box to Card Reader
1. Line 1: Device Type and Device Number
2. Line 2: Panel ID – Port Number
3. Example: CR 001
   PANEL 4 – CR3

D. Miscellaneous Examples:
1. From Door Junction Box to Door Contact
   a. CR001
b. DC

2. From Door Junction Box to Rex Alarm
   a. CR001
   b. REX ALM

3. From Panel to Rex
   a. CR001
   b. REX PWR
   c. 12 VDC

4. From Panel to Lock
   a. CR001
   b. LCK PWR
   c. 24 VDC

E. Communications Cable
   1. Line 1: Communication Type and Direction
   2. Line 2: Panel ID
   3. Example: RS-485 TO PANEL 2

4. Typical Communication Types
   a. RS-485
   b. RS-232
   c. RS-422

END OF SECTION
SECTION 28 08 00 SECURITY SYSTEM ACCEPTANCE TESTING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. General: Furnish engineering, labor, materials, apparatus, tools, equipment, and transportation required to test a completed security system installation as described in these and the related Specifications.

B. Base Bid Work

1. Comprehensive testing for all systems installed as part of the project in two distinct phases which includes:
   a. Functional Testing
   b. Acceptance Testing

2. Produce and submit for review and approval the test results documentation for each of the two distinct phases of testing.

C. Related Sections:

1. Section 28 00 00, “Basic Security Requirements”
2. Section 28 05 13, “Security System Cabling”
4. Section 28 08 00, “Security System Acceptance Testing”
5. Section 28 13 00, “Access Control and Alarm Monitoring System”
6. Section 28 16 00, “Intrusion Detection System”
7. Section 28 23 00, “Video Surveillance System”

1.2 SUMMARY OF ACCEPTANCE TESTING ACTIVITIES

A. Overview

1. The purpose of these testing activities is to ensure the security system operates properly and per the Owner’s requirements. Security systems are very complex from both an equipment and programming standpoint and thorough testing is necessary to ensure correct operation.

2. Perform testing activities after-hours or on weekends when the system is not being actively utilized and the building is generally unoccupied. This will minimize the amount of irrelevant activity in the system activity reports that will be used as a record of the Functional Testing and Acceptance Testing test results documentation.

B. Functional Testing

1. Functional Testing represents a complete and documented test of the security systems. At a minimum, Functional Testing shall demonstrate proper operation of security system components, including: devices, sensors, switches, power supplies, controllers, input/output boards, relays, network communications, tamper switches, initiating circuits, and associated accessories and appurtenances required for system functionality.

2. Perform Functional Testing of security systems to verify correct operation prior to scheduling the Acceptance Testing.

3. Document the results of the Functional Testing and submit to the Engineer along with system activity reports for approval.
4. Functional Testing test results documentation shall be reviewed and approved prior to scheduling the Acceptance Testing.

C. Acceptance Testing

1. Acceptance Testing represents a final walk test with the Engineer and Owner to demonstrate proper operation of security system components including system integration, programming, operational capabilities, and functional performance.
2. Perform Acceptance Testing of the security systems in the presence of the Engineer and Owner to demonstrate fully functional and completely operational security systems.
3. Submit Acceptance Testing test results documentation and punch list/deficiencies corrections, prior to Owner approval of Substantial Completion and the start of the Warranty period.

1.3 SUBMITTALS

A. Functional Testing test results documentation submittal
B. Acceptance Testing test results documentation submittal
C. Operation and Maintenance (O&M) Manuals: Submit O&M Manuals for review and approval at the completion of the project consisting of the following:
   1. Warranty letter: copy of Warranty letter reflecting start and end dates, and instructions covering warranty procedures.
   2. Functional Design Manual: includes a detailed explanation of the operation of the system.
   3. Hardware Manual, which includes:
      a. Pictorial parts list and part numbers
      b. Pictorial and schematic drawings of wiring systems including devices, control panels, instrumentation, and annunciators
      c. Telephone numbers for the authorized parts and service distributors
      d. Service bulletins
   4. Software Manual, which includes:
      a. Use of system and applications software
      b. Initialization, start-up, and shut down procedures
      c. Alarm reports
   5. Operator’s Manual, which fully explains procedures and instructions for the operation of the system and includes:
      a. Computers and peripherals
      b. System start up and shut down procedures
      c. Use of system, command, and applications software
      d. Recovery and restart procedures
      e. Graphic alarm presentation
      f. Use of report generator and generation of reports
      g. Data entry operator commands
      h. Alarm messages and reprinting formats
      i. System access requirements
      j. Service maintenance call procedures
   6. Maintenance Manual, which includes:
      a. Instructions for routine maintenance listed for each component, and a multi-page summary of component’s routine maintenance requirements
      b. Detailed instructions for repair of the security system
      c. A summary of the software licenses, including license numbers, quantity of clients, summary of the software options provided, and database capabilities
d. A list of IP addresses used and with which system component they are associated, including MAC address

e. A list of gateway addresses, subnet masks, DNS servers, and host name information

7. Test Results Manual which includes the document results of tests, required under this Specification, organized by System, Floor, and Door.

8. As-Built Drawings, which includes 11”x17” prints of the as-built drawings.

D. As-Built Drawings

1. Submit As-Built Drawings for review and approval at the completion of the project.

2. As-Built Drawings shall fully and accurately represent installed systems and conditions, including: actual locations of devices and components, actual cable and terminal block numbering, and actual wire routing and wiring (wire type, gauge/size, rating, etc).

3. Record changes in the work during the course of construction on blue or black line prints. Transfer construction mark-ups to AutoCAD or Revit format drawings at the completion of the project.

4. Include the following additional information:
   a. Device addresses and IP address information
   b. Settings for each camera (lens specs, mm setting, auto shutter setting, and other available camera settings, etc.)

5. Include approved Shop Drawings.

6. Final acceptance requires the Engineer’s approval of the As-Built Drawings.

E. Owner’s acceptance, Substantial Completion, and start of the Warranty period requires all submittals above be approved and punch list deficiencies be corrected.

1.4 QUALITY ASSURANCE

A. Provide a project manager to coordinate the security system acceptance testing work with other trades.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 SCHEDULING

A. Coordinate the security system Functional Testing and Acceptance Testing acceptance testing specific activities into the overall project construction schedule.

B. Provide the Engineer and Owner with a minimum one week notice prior to scheduling Functional Testing and Acceptance Testing activities.
3.2 TESTING REQUIREMENTS

A. Site Tests

1. At a minimum, security system testing requirements shall include the following tests (where applicable to the project):
   a. Building Perimeter Test: Test doors, cameras, and devices related to securing the perimeter of the building.
   b. BDF/IDF Test: Test devices related to securing the BDF and IDF. Inspect system panels, power supplies, and other related security equipment located in these areas.
   d. Video Surveillance System Test: Test the system for correct programming, operation, and alarm camera call-up.
   e. Video Recording System Test: Test the recording system for correct programming, alarm recording, and event retrieval. Verify correct integration with the ACAMS and IDS system for alarm call-up. Test and verify the system is viewable from client workstations.
   f. Intrusion Detection System Test: Test the network connection and alarm dialer and duress stations for correct programming and operation. Verify correct arming/disarming functions from each keypad. Verify integration with ACAMS and Video Surveillance System.
   g. Video Camera Test: Review cameras for proper coverage, quality of video, focus, configuration, etc.
   h. Other Readers/Door Test: Test remaining card readers and doors not included in the above tests.
   i. Battery and UPS Load Test: Disconnect AC power to security system equipment to verify battery operation functions and system remains fully operational.
   j. Door Hardware Test: Coordinate with the Division 08 door hardware contractor to resolve electrified locking door hardware failures and door alignment or door closer problems.

B. Site Tests Preparation

1. Provide device identification numbers that differ from or were not included on the original Construction Drawings.
2. Provide a complete system point list.
3. Provide paper and toner for the printer so that an event log can be printed out and attached to the test reports as verification of test sequence and systems response.
4. During testing, provide technicians familiar with the installation to assist with the test. Stage the technicians as follows: one at the host, one at the device being tested, and one runner responsible to furnishing tools, step ladders, etc.
5. Provide radios for use by the Engineer and Owner during testing.
6. Provide pre-programmed access cards for use during testing. Provide one authorized card for each access level. Provide one card with no access authorization. Provide keys for lockset mechanical key override.
3.3 TEST PROCEDURES
A. Follow manufacturer’s written test procedures for each type of device and system.

3.4 FIELD DOCUMENTATION
A. Provide printed system documentation containing detailed wiring diagrams for each security equipment enclosure. Documentation shall include, at a minimum, layout of equipment, elevation detail, complete parts list, and complete wiring diagrams for each security system controller, input/output board, relay, and power supply.
B. Provide a printed service log for each security equipment enclosure. Service log shall include, at a minimum, columns for the following information: date of service, description of work performed, service technician(s), and service company.
C. Neatly fold the printed system documentation and service log and place it inside a clear plastic pocket affixed to the inside door of the security equipment enclosure.

3.5 TRAINING
A. Upon completion of the Acceptance Testing, provide training to the Owner’s representatives, at times convenient to them, in the function and operation as well as the service and maintenance of the security systems.
B. Utilize the production database for the training to give the users project-specific examples from which to learn.
C. Provide 16 hours, minimum, of on-site training by a factory trained representative. Maintain a sign-in sheet with names and dates of persons trained and forward to Owner upon completion of training.
D. Provide for designated Owner’s representatives to attend off-site factory certification training for all systems installed as part of the project, including:
   1. Access Control and Alarm Monitoring System
   2. Video Surveillance System
   3. Intrusion Detection System

END OF SECTION
SECTION 28 13 00 ACCESS CONTROL AND ALARM MONITORING SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. ACAMS, including access control units, input/output units, and card readers
2. ACAMS power supplies
3. Alarm initiating devices, including: magnetic switch contacts and request-to-exit sensors,
4. Power supplies
5. Interface to electric door hardware and ADA door operators
6. Interface to Fire/Life-Safety system
7. Interface to elevator controls
8. Interface to VSS and other security subsystems with bi-directional communication

B. Products Installed but not Furnished under This Section

1. New electric feed-through power transfer hinges
2. Electrified locking hardware cable and termination to transfer hinge and security system

C. Products Specified but not Installed under This Section

1. Access control devices inside elevator cabs, including card readers, interface relays, and reader modules.

D. Products Furnished and Installed under Another Section

1. 120VAC power
2. Telecommunication pathways; refer to Section 27 05 28 and/or 27 05 32.
3. Network switches, with Power over Ethernet (PoE)
4. PoE Door Hardware
5. ADA door operators and push buttons
6. Fire/life-safety system interface relays
7. Electromagnetic door holders
8. Network connectivity for ACAMS devices via Owner's local/wide area network

E. Related Sections

1. Consult other Divisions, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a fully functional and completely operational system.
2. Section 08 71 00, "Door Hardware"
3. Section 14 20 00, "Elevators"
4. Section 28 00 00, "Basic Security Requirements"
5. Section 28 05 13, "Security System Cabling"
6. Section 28 05 53, "Security System Labeling"
7. Section 28 08 00, "Security System Acceptance Testing"
8. Section 28 16 00, "Intrusion Detection System"
9. Section 28 23 00, "Video Surveillance System"
10. Section 28 16 00, "Intrusion Detection System"

1.2 REFERENCES
A. Comply with the References requirements of Section 28 00 00.
B. In addition to the codes and standards listed in Section 28 00 00, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. Underwriters Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
      a. UL 497, “Protectors for Paired-Conductor Communication Circuits”

1.3 DEFINITIONS

A. Definitions as described in Section 28 00 00 shall apply to this Section.
B. In addition to those definitions in Section 28 00 00, the following list of terms as used in this specification defined as follows:
   1. “A” and “AMP”: amperes
   2. “ACAMS”: access control and alarm monitoring
   3. “IDS”: intrusion detection system
   4. “KVM”: Keyboard, Monitor, Mouse (as in KVM drawer to access a server)
   5. “LAN”: Local Area Network
   6. “NC”: Normally closed
   7. “NO”: Normally open
   8. “REX”: request to exit
   9. “SCS”: security communications system
   10. “UPS”: uninterruptable power supply
   11. “VAC”: volts alternating current
   12. “VDC”: volts direct current
   13. “VMS”: video management system
   14. “VSS”: video surveillance system

1.4 SYSTEM DESCRIPTION

A. General: Provide engineering, labor, materials, apparatus, tools, equipment, transportation, temporary construction and special or occasional services as required to make a complete working Access Control and Alarm Monitoring system installation, as described in these specifications.
B. Access Control and Alarm Monitoring System (ACAMS) Overview
   1. The ACAMS is a distributed network of control panels connected to and programmed from an existing host server and client workstations, one located at the District Office and the others at each respective campus.
   2. The ACAMS is utilized for electronically controlling access to students, delivery personnel, and staff entrances to the building(s).
   3. The ACAMS consists of an existing Software House CCURE 9000 server located at the District Office in Martinez, existing client workstations, control panels, card readers, battery powered wireless card readers with integrated locking hardware, wireless interface modules and alarm initiating devices. The host server communicates with the field panels via the Owner’s local/wide area network.
   4. Card reader doors must tie into the existing District-wide host server. Develop schedules to automate the opening and closing of the building(s), including unlocking doors, bypassing alarms, and enabling ADA actuation devices.
   5. Card readers used in classrooms and/or additional locations as identified by the college must include emergency lockdown capability for shelter in place. The lockdown capability will:
      a. Disable the exterior reader and only allow excess via mechanical key only.
b. Notify Police Services via the access control system and/or the intrusion detection system of emergency lockdown alarm event.

6. The ACAMS also provides secondary alarm monitoring and alarm partition control of the IDS control panels through software integration.

C. ACAMS Panels and Power Supplies

1. Provide ACAMS interface software license for IDS control panels and program to enable bidirectional alarm communication for alarm notification and partition arm/disarm control.
2. Provide ACAMS interface software to VSS network video recorders to enable alarm event recording and automatic call up of associated cameras upon alarm activation (forced door, door held open, etc.).
3. Provide ACAMS control panels located in the telecommunication rooms as indicated on project drawings. Coordinate exact location of control panels with local IT department. Panels support up to 16 card readers with locking control outputs and multiple general-purpose input/output modules for automation.
4. Provide proximity wireless card readers with integrated locking hardware. Wireless readers are battery powered.
5. Provide wireless interface modules. Field determine the quantity and exact locations of the wireless interface modules for full coverage of wireless card readers.
6. Provide wireless survey kit to verify wireless interface module placement.
7. Provide input and output modules in a lockable enclosure to support the project specific security system requirements.
8. Provide multi-technology card readers with optical tampers on doors deemed critical to the security of assets subject to a high possibility of theft, sensitive information, or other areas of critical nature and doors with operational requirements such as building entrances, as noted on the project drawings.
9. Provide alarm contacts and request-to-exit motion detectors for card reader-controlled doors. Include output from ACAMS to indicate alarm contact status to IDS.
10. Provide alarm contacts for non-card reader controller perimeter doors as indicated on project drawings.
11. Provide audible alarms at monitored emergency exit-only doors and special card reader doors as indicated on project drawings. Local audible alarms to sound upon alarm activation (forced door, door held open, etc.). Provide monitoring of the key switch and remote reset through the ACAMS.
12. Utilize IDS integration to monitor motion detector and duress alarms through the ACAMS workstation. Provide interface to ADA automatic/power assist door operator and corresponding actuator push plates or optical motion detection actuators.
   a. When door locked, exterior push plate/optical sensor is disabled
   b. When door unlocked, even momentarily, push plate/optical sensor is enabled.
   c. Interior push plate/optical sensor unlocks door and always triggers automatic door operator.
13. Provide 12/24VDC ACAMS device and lock power supplies as indicated on project drawings with enclosure tamper switches.
14. Provide battery backup of system components and power supplies.

D. Card Readers / Door Devices

1. Provide multi-technology card readers, including rough-in, wiring, reader, and other components for a complete system and connect to the ACAMS. Provide tamper switches per card reader wired/connected to the ACAMS input module.
2. Provide door contacts and request-to-exit motion detectors for card reader-controlled doors and connect to the ACAMS. Refer to drawings for configurations and instances.
3. Provide double pole double throw contacts on doors controlled by card readers with associated IDS alarm monitoring keypads. Wire one contact to the serving ACAMS panel and connect to the ACAMS panel as an input.

4. Provide door contacts for non-card reader-controlled doors noted on drawings (such as ground floor perimeter doors) and connect to the ACAMS. ACAMS shall monitor these doors. Program the ACAMS to alarm should the monitored doors open when not authorized.

5. PoE Integrated door hardware (where the card reader is integrated into the door hardware) is specified and installed under division 8. Division 28 contractor to coordinate functionality and program in access control system. Refer to Division 08 71 00 Door Hardware for PoE lock coordination.

6. Program PoE hardware with integrated card reader to support emergency classroom lockdown using an integrated push button. Emergency classroom lockdown locks the door and disables the integrated card reader.

E. Tamper Monitoring
1. Provide additional monitor input points for monitoring the following:
   a. Tamper switches located within each security equipment enclosure and wireway (use unsupervised inputs for this purpose).
   b. Supervision of power supplies and batteries (use unsupervised inputs for this purpose).
   c. Tamper switches located within each door junction box.

F. Provide interface to ADA automatic/power assist door operator and corresponding actuator push plates

G. Fire/Life-Safety System Interface
1. Coordinate with Fire/Life-Safety system contractor to automatically drop power from stairwell, elevator vestibule lobby, and other doors within the path of egress upon alarm activation of the Fire/Life-Safety system.

2. Coordinate with Fire/Life-Safety system contractor for scheduled release of electromagnetic door holders on designated card reader doors or scheduled unlocked doors as indicated on project drawings. Provide ACAMS output modules as necessary to interface with Fire/Life-Safety system to release electromagnetic door holders on doors that are required to close and lock on scheduled events.

3. Provide emergency door release pull stations with double pole, double throw contacts located in elevator vestibule lobbies as indicated on project drawings. First set of contacts to break power to electrified door hardware on adjacent card reader door. Second set of contacts to connect with ACAMS. Provide ACAMS input modules as necessary to monitor status of emergency door release pull stations.

H. Elevator Interface
1. Provide a card reader in the elevator cabs shown on the drawings. In-cab card readers shall activate call buttons and control access to individual floors.

2. Provide interface between ACAMS and elevator controls. Program ACAMS with elevator interface based on the Owner’s access level policy.

3. Provide coordination during installation of card reader and cable terminations with elevator contractor. Elevator contractor to provide card reader cable in elevator travelling cable, to install the card reader into the elevator cab panel, and to connect the elevator control panel to the security junction box. ACAMS contractor to provide the security junction box, including terminal blocks and associated components, and connect the security junction box to the ACAMS panel as output points.
4. Elevator contractor responsible for elevator traveler cable, connection from elevator controller to security termination junction box, and installation of card readers within the elevator cabs.

5. Provide an output from the ACAMS system to the elevator control system, wired through the security termination junction box (at the elevator control rooms). Provide interface relays between ACAMS and elevator controller.

6. Provide coordination during installation of card reader and cable terminations with elevator contractor.

I. Extra Materials

1. Furnish 10% spare parts of total installed the following (round up to the next complete device):
   a. Access controller boards
   b. Input expansion modules
   c. Output expansion modules
   d. Reader interface modules
   e. Card readers
   f. Power supply boards
   g. Relays

2. Fuses: 5 of each type of fuse

1.5 SUBMITTALS

A. Quantity: Furnish quantities of each submittal as noted in Section 280000.

B. Contractor Qualifications: Submit certification letters for the manufacturer of the ACAMS.

C. Product Data: Submit product information for components specified herein.

D. Shop Drawings: Include the following, minimum:
   1. Device placement on floor plans and RCPs
   2. Point-to-Point Diagrams: Include wiring, points of connection and interconnecting devices between the following:
      a. ACAMS control panel
      b. ACAMS card reader and input/output modules
      c. ACAMS power supplies
      d. Card Readers
      e. Door and lock position monitoring contact switches and request-to-exit sensors
      f. Interface to electrified door hardware
      g. Interface to Fire/Life-Safety system
      h. Interface to elevator controller
      i. Hardwired interfaces to IDS
      j. Cable conductors (identify conductors on the point to point diagrams with the same tag as the installed conductor)
      k. Miscellaneous control relays
   3. Block Diagram/Riser Diagram: Show ACAMS components, conduit, wire types, and sizes between them, including cabling interties between termination hardware.
   4. Schedules: Include schedules for ACAMS control panels that show each point ID with a description of the connected devices
   5. Include user interface graphics with icons and control buttons displayed.
   6. Include custom mounting details.
E. Submittal Description: Training Submittal

1. Format: PDF
2. Contents:
   a. Cover sheet, showing:
      1) Owner Name
      2) Project Name and Address
      3) Project Submittal Number
      4) Submittal Name
      5) System Name
      6) Specification Section Number (e.g., “Section 28 13 00”)
      7) Date of Submittal. Format: Month Day, Year (e.g., “January 1, 2020”)
      8) Contractor Name
   b. Table of Contents
   c. Training Schedule
   d. Training Course outline/ agenda
   e. Course materials and training manuals for the following users as applicable:
      1) System Administrator
      2) Security staff
      3) Operator, and nurse/staff.

F. Submittal Requirements at Closeout:

1. As-Built Drawings: submit as-built drawings that includes approved block diagram, riser diagram, wiring diagram, security control room layout and elevations, floor plans, and reflected ceiling plans, and site plans showing device locations.
2. O&M Manual: submit O&M Manual as a binder or soft copy (bookmarked PDF) including the following, at a minimum:
   a. Product data – approved submittals (‘cleaned up’) and electronic
   b. As-built drawings, printed to 11x17 / tabloid landscape and electronic PDF files and native files (DWG or RVT) on storage media
   c. Warranty statement and service protocol (guidelines, contact numbers, etc.)
   d. Maintenance requirements
   e. Station Matrix, printed to 11x17 / tabloid landscape and electronic PDF files and native XLSX file on storage media
   f. Include information for the network switches and ports.

1.6 WARRANTY

A. Warrant work and the system to perform as described within this Section for a period of one year from the date of system acceptance. The warranty shall cover system operation/performance, parts, and labor. During the warranty period, respond within 4 hours and correct deficiencies within 24 hours of notification.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Access Control and Alarm Monitoring System
   1. Software House

B. Card Readers
   1. HID

2.2 SECURITY EQUIPMENT ENCLOSURES AND DEMARCATION ENCLOSURES

A. Refer to 280000 for product requirements.

2.3 SLOTTED WIRING DUCT

A. Refer to 280000 for product requirements.

2.4 WIREWAYS

A. Refer to 280000 for product requirements.

2.5 POWER SUPPLIES/BATTERY CHARGERS

A. Power supplies shall be UL Listed and suitable for powering ACAMS controllers, reader boards, intrusion detection panels, electric locks, and field devices (such as REXs, local alarms, etc.). Power supplies shall also be suitable for continuous charging of batteries (for power back up).

B. Description / Features:
   1. Input: 120 VAC, hard-wired
   2. Output: sixteen 12 VDC and/or 24 VDC, 10 A continuous current, PTC Class 2 rated power limited
   3. Fire alarm disconnect, individually selectable per output
   4. Short circuit and thermal overload protection
   5. Fail Safe and/or Fail Secure power outputs, individually selectable per output
   6. LEDs indicate outputs triggered
   7. Integrated charger for sealed lead acid or gel type batteries
   8. Enclosure with integrated tamper switch
   9. Monitor loss of input power and alarm in the Access Control System
   10. Manufacturers, or equal:
       a. Altronix MAXIMAL Series; 12 VDC and 24 VDC dual power supply
       b. LifeSafety Power #FPO150-C8E1; 12 VDC power supply
       c. Securitron #AQD6-8F; “AccuPower” switching power supply, 8-output
       d. Securitron #AQD6-8F8R; “AccuPower” switching power supply, 8-output with relays

2.6 BATTERIES
A. Batteries shall be UL Listed and suitable for the purpose of backing up power to security system equipment, field devices, electric locks, etc.

B. Description / Features:
   1. Voltage: 12 VDC
   2. Amps: 12 A
   3. Chemistry: SLA or VRLA
   4. Termination: Spade protected terminals

C. Manufacturer, or equal:
   1. Interstate Batteries #SLA1105 sealed lead acid 12V 12Ah battery
   2. Yuasa Battery Inc #RE12-12 sealed lead acid 12V 12Ah battery

2.7 ACCESS CONTROLLERS

A. Description / Features:
   1. An intelligent controller with integrated battery backup, database, and communication ports that supports 32 card readers
   2. Supports HID proximity, MIFARE, and DESFire card reader formats
   3. Expansion capacity/additional modules (e.g., for additional memory and/or for future feature enhancements)
   4. Supports flash upgrades for firmware updates
   5. Global input/output and anti-pass back functionality
   6. Capable of utilizing keypad commands to activate/deactivate events
   7. Monitor Inputs: Station switch, tamper, power fail, and alarm

B. Functions:
   1. Central control for attached devices
   2. Makes decisions for access
   3. Responds to monitor activity
   4. Receives input to control its decision making
   5. Reports activity to other devices

C. Mounting: within wall mounted NEMA enclosure

D. Power:
   1. Main Power Source: controller shall be powered from the associated power supply unit
   2. Battery Backup: the controller board shall have an integrated low voltage battery (such as a lithium cell) to maintain internally stored database and setup in case main power is interrupted

E. Self-Protection: Controller shall detect power input failures and tampering

F. Communications
   1. TCP/IP via 10Base-T/100Base-TX
   2. Supports multiple communication channels to which a variety of devices can connect – RS-485, RS-422, or 20mA communications to addressable modules:
      a. Input Module: Supports 16 Class A supervised input points
      b. Output Module: Supports 16 Form C dry contact relays
      c. Reader Interface Module: Supports 4 card readers with associated alarm contacts, request-to-exit devices, and lock outputs

G. Manufacturer:
1. Software House “iSTAR” series
   a. iSTAR Ultra
   b. #I8 input module
   c. #R8 output module
   d. #RM-4E four-reader interface module

2.8 MONITOR INPUT/RELAY OUTPUT BOARDS

A. Description
   1. Monitor Input: module that monitors inputs that occur over network and sends them via
      RS-485 protocol to the Controller.
   2. Relay Output: executes relay commands received from the Controller via RS-485
      protocol.
   3. Monitor Inputs: 8, minimum, four-state monitor points
   4. Relay Outputs: 8, minimum, normally opened (NO) or normally closed (NC)

B. Manufacturer, or equal:
   1. Input Module:
      a. Software House #I/8
   2. Output Module:
      a. Software House #R/8

2.9 CARD READERS

A. Description / Features:
   1. FCC and CE certified, and conform to the following ISO standards:
      a. 15693 (CSN read-only)
      b. 14443A (CSN read-only)
      c. 14443B (CSN read-only)
   2. Capable of reading the following frequencies and card formats:
      a. 125 kHz and 13.56 MHz
   3. Utilize a Wiegand protocol for communication for compatibility with standard access
      control systems.
   4. Multi-color LED and an audible sounder to indicate the status of the door
   5. For exterior locations, reader shall be fully weatherized with a rugged, polycarbonate
      enclosure, designed to withstand an operating temperature of -22 to 150 degrees
      Fahrenheit (-30 to 65 degrees Celsius) and operating humidity of 5-95% non-condensing.

B. Functions:
   1. Card reader shall continuous emit radio radiation with a continuous sensing of an access
      card.
   2. Upon reading an access cord, the card reader shall initiate a single transmission to the
      ACAMS controller.
   3. Upon receiving status from the ACAMS controller, the card reader shall change the state
      of the LED to the programmed state.
C. Manufacturer, or equal:
   1. HID multiCLASS series
      a. Wall mount: HID SE Series; multi-technology card reader
      b. Wall mount with keypad: HID SE Series with keypad; multi-technology card reader with integrated keypad
      c. Mullion style: HID SE Series mullion; multi-technology card reader

2.10 MAGNETIC CONTACT SWITCHES

A. Magnetic contact switches shall be UL 634 Listed.
B. Wood, Steel, and Hollow Metal Doors
   1. Description / Features
      a. Mounting: Recessed
      b. Switch Type: Double Pole, Double Throw
      c. Gap Distance: 0.5” maximum
   2. Manufacturer, or equal:
      a. Interlogix #1078C; 3/4" dia., closed-loop contact switch, with leads
      b. Magnasphere #MSS-19CL; 3/4" dia., open loop contact switch, with leads
      c. Magnasphere #HSS-L2C; UL 264 Level 2 high security recessed contact switch, with leads

2.11 REQUEST-TO-EXIT SENSORS

A. General
   1. Power: 12 or 24VDC, 35mA
   2. Relay Output: 2 form “C” contacts
   3. Adjustable relay latch time
   4. Programmable Fail Safe or Fail Secure Modes
   5. Programmable retrigger or non-retrigger mode
   6. Radio Frequency Interference (RFI) Immunity range from 26 to 1,000 MHz at 50 v/m

B. Manufacturer, or equal:
   1. Bosch #DS160 with TP160 trim plate
   2. Honeywell #IS320WH with IS310WHTP trim plate
   3. Interlogix #RCR-REX motion sensor REX

2.12 EMERGENCY LOCKDOWN STATION

A. General
   1. Manual push button type device, blue housing with the words: "LOCKDOWN" inscribed in white on the face
   2. Pressing the emergency button locks down exterior doors and generates alarm
   3. Wall-mounted with alarm monitored lift cover
   4. Audible alarm when cover is lifted
B. Manufacturer:
   1. Safety Technology International
      a. Stopper® Stations #SS2489LD-EN

2.13 TERMINAL BLOCKS

A. Terminal blocks/modular terminal strips shall be suitable for inside equipment enclosures/junction boxes for demarcation of elevator traveler and security cabling.
B. Provide DIN rails and other mounting accessories for a complete installation.
C. Description:
   1. Push-in style bridging system that utilizes the IDC termination method
   2. DIN rails mounting (standard 35mm)
   3. Feed through style, single level
D. Manufacturer, or equal:
   1. Phoenix Contact #QTC-1,5 terminal block and #NS-35/7,5 DIN rail
   2. ABB Entrellec feed through terminal blocks
   3. Weidmuller P-Series feed through terminal blocks

2.14 INTERFACE RELAYS

A. Refer to section 28 00 00 for relay product requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General
   1. Install equipment per manufacturer’s instructions.
   2. Install devices, stations, etc., square and plumb. Set flush-mounted units so that the face of the cover, bezel, or escutcheon matches the surrounding finished surface.
   3. Install so that there are no gaps, cracks, or obvious lines between the trim and the adjacent finished surface.
   4. Install to heights shown on drawings. Heights shall comply with applicable ADA requirements.
   5. Provide supervisory and end of line resistors as required.
B. ACAMS Control Panels (Reader Board, Input/Output Boards)
   1. Install security equipment enclosures and wireway per approved shop drawings.
   2. Ensure cuts, knock-outs, punches, etc. have no sharp edges.
   3. Install power supplies and associated hardware in same location.
C. Wireless Interface Module
   1. Field determine best location for wireless card reader interface module. Locate module above accessible ceiling, whenever possible to avoid damage to units.
   2. Connect wireless interface module to ACAMS panel using the RS-485 data bus.
D. Remote Reader Modules
1. Locate remote reader module in accessible ceiling space unless otherwise noted on the project drawings.
2. Power remove reader modules from power supply located at centralized security hub.

E. Card Readers
1. Install card reader to the rough-in, not directly to dry wall.
2. Connect readers directly to reader boards. Do not daisy chain readers together.
3. Cable Requirements:
   a. 6-conductor 22 AWG stranded shielded cable for signal.
   b. 1-pair 22AWG stranded shielded cable for device power.
4. Wire the card reader’s multi-color LED to indicate the following status of the door.
   a. Red = the door is secure (locked).
   b. Green = the door is unsecured (unlocked).
   c. Yellow = the card reader is not functioning (off-line/trouble), is processing a read request, or has denied access.
5. Wire/program the card reader to produce an audible beep tone to indicate to the user:
   a. The card was read and/or access was denied.
   b. Door is being held open and needs to be closed.
6. Enable optical tamper using configuration card. Wire the card reader’s optical tamper to spare input on the ACAMS reader module and jumper ground wire from door contact to provide a normally closed circuit.

F. Four-State End-of-Line (EOL) Supervision
1. Provide designated resistors at device end of line per manufacturer’s EOL recommendation to provide four-state supervision of security device and cabling.
2. Provide EOL supervision for alarm contacts, local alarm sounders, REXs, motion detectors, glass break detectors, help/duress buttons, and other designated security devices connected to the ACAMS and IDS.
3. Program ACAMS with the following states of supervision:
   a. Contact closed = Secure
   b. Contact open = Alarm
   c. Short circuit = Line fault
   d. Open circuit = Line fault
4. All NO/NC circuits shall be wired NC.

G. Elevator Card Readers and Interface with Elevator
1. Coordinate with the elevator contractor the installation of the card reader inside the cab.
2. Furnish card readers to elevator contractor for their installation in the cab.
3. Coordinate with elevator contractor to connect ACAMS output relays to elevator controller.
4. Install the elevator demarcation junction box as near as possible, but not within, the elevator machine room while remaining accessible. Install terminal blocks/modular terminal strips, DIN rails, and other accessories inside the elevator demarcation junction box. Route security wiring to terminal blocks and terminate on one side – the other side shall remain available for wiring from the elevator machine room.
H. Door Hardware
   1. Setup and conduct a door hardware coordination meeting.
   2. Coordinate the installation and termination of the security cable with the installation of the electric door hardware and transfer hinge.
   3. Route power to electrically controlled locks on Life-Safety doors through fire alarm output to automatically unlock the door upon activation of Fire/Life-Safety system. Connect fire alarm output to the disconnect relay on the associated 24VDC lock power supply.
   4. Coordinate the installation and termination of the patch cord from the network drop with the installation of the PoE door hardware and PoE transfer hinge. Refer to Specification 271513 for patch cord requirements.
   5. Provide cable and terminate wires to delayed egress devices for monitoring activation of delayed egress by the ACAMS system.

I. Door Contacts
   1. Install on protected (secured) side of door.
   2. Install 6" from latch side of 3 door.

J. Request-To Exit Motion Detectors
   1. Install motion detector on the secured (protected) side of door. Install so that its detection pattern is not obstructed by exit signs, light fixtures or other objects that would interfere with proper operation.
   2. Adjust relay hold time and pattern to properly detect valid exit and allow shunting of door contact.
   3. Adjust detection sensitivity to pulse.
   4. Mask detector lens to provide a confined detection area limited to the door handle or push bar.
   5. Run wire inside structural tube steel frame into back of conduit body for cage locations.

K. Low voltage transformers
   1. Install low voltage transformer in security junction box to prevent tampering. Coordinate with Division 26 for location of outlet in junction box.

3.2 PROGRAMMING

A. Prior to the completion of construction, schedule a meeting with the Owner to determine the programming criteria. Document the results of the meeting and perform necessary programming to achieve the Owner’s requests. During the meeting, discuss the following:
   1. Door and device names
   2. Access card levels and door groupings
   3. Alarm priority levels
   4. Schedules and time codes
   5. Holidays and holiday types (priorities)
   6. Action/responses from individual input points
   7. Standard and custom (expanded) reports
   8. Defining alarm messages and standard response messages applicable to site
   9. Routing of alarm points to and operator’s workstations, printers, and history files
   10. Owner’s graphics – develop sample graphic complete with icons and text. Alarms to appear on building floor plans depicting the nature and location of alarms. Review and revise graphic layout as required by Owner.
   11. System database backup procedures
   12. Video integration camera call-up
B. Document the results of the meeting and perform necessary programming to achieve the Owner’s requests.

C. Program and setup the system such that no additional programming other than entering new access cards is required. Include setup of available features of the software.

D. Import Owner’s cardholder database.

E. Using CAD drawing files of floor plans, perform the following relative to system graphics:
   1. Delete non-applicable drawing layers and details to arrive at simple floor plans of the building as built.
   2. Convert drawings to a graphic file format compatible with the Owner’s access control and alarm monitoring system.
   3. Load drawing files into the system.
   4. Apply new and predefined icons and other points on each graphic to indicate point and control status.
   5. Link graphic images/icons to represent reader, monitor, alarm initiating devices, and control points.
   6. Program device icons on plans with functionality.
   7. Create camera call-up events.
   8. The point names shown on the as-built drawings shall match the system point schedule.

F. Program ACAMS such that alarm events generate email notification to offsite addresses via the Internet. Also, as required by the Owner, program ACAMS such that alarm events generate pages.

G. Program customized client workstation log-ins (restrict functions by user privileges).

H. Program routing of monitor and control points. Route activations and restore messages to one or more of the following locations as directed by the Owner’s Representative:
   1. One or more system workstations
   2. One or more system printers
   3. One or more alphanumeric pagers
   4. History files in addition to the above
   5. History files only

I. Program the system such that reliance on a remote host for routine building operations, such as scheduled door commands and conditional events, are minimized to the greatest extent possible and decisions are made at the local building controller.

J. System Operation, Alarm and Reporting Function: Program door control panel tamper switches to immediately report as a separate “tamper” point to the system resulting in an alarm condition displayed in both text and graphic form on the applicable workstation(s) and an alarm message transmitted to the appropriate pager(s).

K. Program the system in a manner that minimizes the amount of time required for the users to make updates and maintain the system on a daily basis especially updates that impact card holder record updates. Nested programs, such as reader groupings used in access codes, shall be used to the greatest extent possible such that single actions are required to update an entire card data population. If there is a question regarding the appropriate approach to programming, given the flexibility of most systems, contact the Engineer prior to any initial programming.

L. Perform 2 full system back-ups at completion of initial programming and deliver one copy to owner with letter of Transmittal explaining information included in back-up and brief description of recovery procedures. Label the second removable storage device and store onsite. Perform back-ups on a regular bases through the remainder of the project.

M. Customize menus with the assistance of the factory to “gray-out” features not used on project (such as elevator control).

N. Perform field software changes after the initial programming session to “fine tune” operating parameters and sequence of operations based on revised operating requirements.

O. Password management – refer to Section 28 00 00.
3.3 EXTRA MATERIALS

A. Furnish extra materials to Owner. Produce a transmittal with an itemized list including quantities, recipient, and receipt date. Submit copy of Owner-signed transmittal with project closeout documents.
B. Place fuses inside each equipment/panel and power supply enclosure.
C. Turn over keys (equipment enclosures, low voltage power supplies, security junction boxes, rack cabinets, etc.) to the Owner. Produce a transmittal with an itemized list of keys, recipient, and receipt date. Submit copy of Owner-signed transmittal with project closeout documents.

3.4 TRAINING

A. Combine training on the ACAMS with training on the IDS (Section 28 16 00) and the VSS (Section 28 23 00).

3.5 TESTING

A. Test ACAMS in accordance with Section 28 08 00.

END OF SECTION
SECTION 28 16 00 INTRUSION DETECTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. General: Furnish engineering, labor, materials, apparatus, tools, equipment, transportation, temporary construction, and special or occasional services required to make a complete working intrusion detection system installation as described in these specifications.

B. Section includes:
   1. Intrusion Detection System, including digital communicator, keypad, and alarm devices.
   2. Door contacts, glass break detectors, motion sensors
   3. Duress alarm signal from ACAMS
   4. Interfaces and connections between intrusion detection subsystems to allow communication with one another

C. Products furnished and installed under another section:
   1. 120V power
   2. Network connectivity for IDS Panel via Owner’s local/wide area network
   3. Door alarm contacts
   4. Phone line

D. Related sections:
   1. Section 28 00 00 – Basic Security Requirements: for submittal format, warranty, general product requirements, and installation requirements
   2. Section 28 13 00 – ACAMS: for interface requirement to the IDS
   3. Section 28 05 13 – Security System Cabling: for cable requirements
   4. Section 28 05 53 – Security System Labeling: for device labeling requirements
   5. Section 28 08 00 – Security System Acceptance Testing: for testing requirements

1.2 SYSTEM DESCRIPTION

A. Overview
   1. The IDS is comprised of multiple areas that can be armed and disarmed independently of each other.
   2. The IDS is utilized for after hours monitoring of the Fireside, Classroom, and Student Activities Buildings, including the Bookstore, and 24 hour monitoring of the duress buttons.
   3. Activation of the IDS dials a remote, third party central station to first contact Police Services on campus then dispatch the San Pablo Police Department.
   4. The IDS integrates with the ACAMS through software to send alarm information for secondary monitoring with the ACAMS.

B. Intrusion Detection System
   1. Provide an IDS control panel with integrated UL listed digital communicator located in the Fireside, Classroom, and Student Activities Buildings telecommunication rooms as indicated on project drawings. Panels support up to 8 areas and 64 zones by use of addressable input/output point modules.
   2. Provide LCD command keypads as indicated on project drawings. Keypads allow for system arming and disarming by authorized users.
   3. Provide wireless back up alarm communicator.
4. Provide alarm contacts for non-card reader controller perimeter doors as indicated on project drawings.
5. Provide under counter duress buttons as indicated on project drawings. Program duress alarm inputs as 24 hours zones.
6. Provide motion sensors as indicated on project drawings.
7. Utilize double pole double throw alarm contacts from the ACAMS card reader doors as indicated on project drawings.
8. Provide 12VDC auxiliary power supply to support the field devices indicated on project drawings.
9. Provide battery backup of IDS components and power supplies for a minimum of 24 hours in the event of a power failure or emergency.

C. Interface with ACAMS
   1. Connect ACAMS alarm contact double-pole-double-throw contact to the IDS control panel. Provide expansion modules as necessary to support the security devices shown on the project drawings.
   2. Utilize existing ACAMS and IDS integration software license as required.
   3. Integrate IDS with ACAMS for alarm monitoring and alarm partition arming/disarming through existing ACAMS workstation(s).

D. Tamper Monitoring
   1. Provide additional monitor input points for monitoring the following:
      a. Tamper switches located within each security equipment enclosure and wireway (use unsupervised inputs for this purpose).
      b. Supervision of power supplies and batteries (use unsupervised inputs for this purpose).

1.3 SUBMITTALS

A. Product Data: Submit product information for the intrusion detection systems, including:
   1. IDS control panel
   2. Keypads
   3. Cellular backup communicator
   4. Duress buttons
   5. Motion sensors
   6. Alarm contacts
   7. Power supplies
   8. Calculations for backup batteries

B. Shop Drawings: Submit shop drawings containing the following:
   1. Device placement on floor plans
   2. Point-to-Point Wiring Diagrams: Include wiring, points of connect, and interconnecting devices between the following:
      a. IDS control panel
      b. IDS expansion modules and relays
      c. Keypads
      d. Motion sensors
      e. Alarm contacts
      f. Local audible alarms
      g. Power supplies
      h. Cable conductors (identify conductors on the point-to-point diagrams with the same tag as the installed conductor)
   3. Schedules: Provide schedules for the IDS control panel that show each alarm zone, applicable area or partition, and a description of the connected device.
   4. Custom mounting details
1.4 EXTRA MATERIALS

A. Provide 10%, of the total installed, spare parts for the following: (Round up to the next complete device)
   1. Fuses
   2. Motion sensors
   3. Duress buttons

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Intrusion Detection System
   1. DSC, to integrate with Software House ACAMS headend

2.2 IDS CONTROL PANELS

A. General
   1. Integrated UL listed digital communicator with phone line monitor (loop or ground start)
   2. Supports up to 64 alarm zones and 8 programmable areas or partitions
   3. Capable of utilizing multiple telephone numbers, primary and duplicate paths with main and alternate destinations
   4. Capable of utilizing a dual phone line switcher to monitor 2 phone lines
   5. Capable of sending daily automatic test and status reports
   6. Supports supervised expansion and relay output modules
   7. Supports RS-232 connectivity to third party devices for automation
   8. Capable of utilizing a TCP/IP converter for Ethernet connectivity

B. Manufacturer
   1. DSC PowerSeries #PC1864 8-64 zone control panel
      a. Accessories
         1) DSC #PC5200 Power Supply Module
         2) DSC #PC5204 Power Supply Module
      b. Expansion modules
         1) DSC # PC5100 Addressable Xone Expander
         2) DSC # PC5108 8-Hardwire Xone Expander
         3) DSC # PC 5208 Programmable Output Module
         4) DSC #TL250GS Internet Alarm Communicator
      c. Wireless back-up communication device
         1) DSC #GS3060; Universal Wireless Alarm Communicator

2.3 IDS KEYPADS

A. General
   1. 32-character display
   2. Keys light on entry or key press
   3. Back lighted multi-key touch pad
   4. User controlled brightness and loudness

B. Provide the ability to display for each detection point:
   1. Alarm
   2. Trouble
   3. Supervisory
   4. Faulted
   5. Custom text
C. System wide displays include:
   1. Local system test
   2. Sensor reset
   3. Event log

D. Manufacturer
   1. DSC #PK5500 64-Zone LCD Full-Message Keypad

2.4 MAGNETIC CONTACT SWITCH

A. Steel Doors:
   1. Mounting: Recessed
   2. Contacts: Single Pole, Single Throw
   3. Gap Distance: 0.5"
   4. Manufacturer:
      a. Sentrol #1078 closed-loop, 1" diameter
      b. GRI #180RS-12 closed loop, 1" diameter
      c. Or equal

2.5 GLASS BREAK SENSOR

1. Ceiling Mount
   a. DSC #DG-50AU
   b. Bosch DS1101i Series
   b. Or Equal

2.6 DURESS BUTTONS

B. Under-Counter
   1. General
      a. Actuating lever, housing, and cover plate made of ABS fire-retardant plastic
      b. Latching circuit with integrated LED
      c. Contact: Normally Open or Normally Closed electrical loop, SPDT
      d. Operating Voltage: 12VDC
   2. Manufacturer
      a. GE Security #3040 panic switch
      b. Or Equal

2.7 MOTION SENSORS

C. General
   1. Type: Passive infrared (PIR) detector with Fresnel type lens
   2. Operating Voltage: 10-14VDC
   3. Range: 35’ x 35’ minimum
   4. Integrated tamper switch

D. Manufacturer
   1. Wall mount
      a. Bosch # ISC-BPR2 blue line PIR detector
      b. Or Equal
   2. Ceiling Mount
      a. Bosch # DS938Z panoramic PIR detector
      b. DSC # BV-500 PIR detector
      c. Or Equal
2.8 IDS POWER SUPPLIES

E. General
1. Provides a 120VAC to 12/24VDC output, fully supervised power supply to power IDS field devices.
2. Utilizes 16 PTC Class 2 rated power limited outputs.
3. Short circuit and thermal overload protection.
4. Integrated charger for sealed lead acid or gel type batteries.
5. Capable of providing 6 amp supply current.

F. Manufacturer
1. Altronix # AL600ULXPD16CB multi-output power supply/charger
2. Or Equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. General
1. Follow manufacturers recommended guidelines for installation.

B. Components
1. IDS Control Panel
   a. Place control panel and associated expansion boards in large NEMA Type-1 enclosure with ACAMS equipment.
   b. Utilize ACAMS power supplies to power control panel and associated expansion boards. Do not use plug-in transformers.
   c. Provide standoff brackets to mount control boards to perforated panel within enclosure.
   d. Place power supply and associated hardware in same location.
   e. Install supervisory and end-of-line resistors for security field devices.
   f. Coordinate installation of phone jack and network connection in IDS control panel enclosure for communications to the contracted central station and integration with ACAMS.
2. Keypads
   a. Mount keypads as indicated on project drawings.
   b. Place one keypad adjacent to or on the IDS control panel enclosure for local service and programming.
3. Duress Buttons
   a. Mount duress buttons under work desks as indicated on the project drawings.
   b. Coordinate with architect and casework contractor to field determine exact placement prior to installation.
4. Motion Sensors and Glass Breaks
   a. Mount motion detectors as indicated on project drawings. Verify current location to maximize coverage prior to installation.
   b. Install detectors so that detection pattern is not obstructed by objects that would interfere with proper operation.

3.2 PROGRAMMING

A. Prior to the completion of construction, schedule a meeting with the Owner to determine the following programming criteria:
1. Zone or alarm point descriptions
2. User authority levels to arm/disarm areas or alarm partitions
3. Auto arm/disarm schedules
4. Interface requirements with ACAMS
5. Central station response from individual alarm points
6. Central station password and call list information

B. Document the results of the meeting and perform necessary programming to achieve the Owner’s requests. Program and setup the system such that no additional programming other than entering new access codes is required.

3.3 TESTING

A. Commission the Intrusion Detection System in accordance with Section 28 08 00.

END OF SECTION
SECTION 28 23 00 VIDEO SURVEILLANCE SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes
   1. Video Surveillance System (complete system)
   2. Video Management System (software)
   3. Fixed cameras, lenses, mounts, and housings
   4. Panoramic cameras, lenses, mounts, and housings
   5. Power Supplies

B. Products Furnished But Not Installed Under This Section
   1. None

C. Products Installed But Not Furnished Under This Section
   1. None

D. Products Specified But Not Installed Under This Section
   1. None

E. Products Furnished And Installed Under Another Section
   1. 120VAC power
   2. Telecommunication cabling between telecom room and cameras; refer to Section 27 15 13.
   3. Network switches, with Power over Ethernet (PoE)

F. Related Sections
   1. Consult other Divisions, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable system.
   2. Section 27 15 13, “Communications Horizontal Cabling”
   3. Section 27 13 23, “Communications Backbone Fiber Optic Cabling”
   4. Section 28 00 00, “Basic Security Requirements”
   5. Section 28 08 00, “Security System Acceptance Testing”
   6. Section 28 05 13, “Security System Cabling”
   7. Section 28 05 53, “Security System Labeling”
   8. Section 28 13 00, “Access Control and Alarm Monitoring System”
   9. Section 28 16 00, “Intrusion Detection System”

1.2 REFERENCES

A. Comply with the References requirements of Section 28 00 00.
B. In addition to the codes and standards listed in Section 28 00 00, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
   1. Underwriters Laboratories (UL): Applicable listing and ratings, including but not limited to the following standards:
1.3 DEFINITIONS

A. Definitions as described in Section 28 00 00 shall apply to this Section.

B. In addition to those definitions in Section 28 00 00, the following list of terms as used in this specification defined as follows:

1. “A” and “AMP”: amperes
2. “ACAMS”: access control and alarm monitoring
3. “CCD”: charge-coupled device
4. “CMOS”: complementary metal oxide semiconductor
5. “DSP”: digital signal processing
6. “FC”: foot candles
7. “FPS”: frames per second
8. “IDS”: intrusion detection system
9. “KVM”: keyboard, video, mouse switch
10. “NAS”: network-attached storage
11. “NVR”: network video recorder
12. “PoE”: Power over Ethernet
13. “PTZ”: pan-tilt-zoom
14. “RAID”: redundant array of independent disks
15. “SAN”: storage area network
16. “VAC”: volts alternating current
17. “VDC”: volts direct current
18. “VMS”: video management system
19. “VSS”: video surveillance system

1.4 SYSTEM DESCRIPTION

A. General: Provide engineering, labor, materials, apparatus, tools, equipment, transportation, temporary construction, and special or occasional services as required to make a complete working video surveillance system, as described in this specification.

B. Video Surveillance System (VSS) Overview

1. The VSS is an enterprise-wide system generally comprised of fixed and panoramic cameras (with associated mounting apparatus, housings, cabling, etc.), video management system (software), and network video recorder and storage (provided by owner), that provides live video feeds for real-time surveillance and monitoring, recorded video for forensic analysis, and (in some cases) intrusion detection through video analytics.

2. The VSS serves as the video component of the facility’s overall security and safety program. Camera deployment and their respective field-of-views are strategically determined to coincide with points of security and access control as well as surveillance of open and high-security spaces.

3. The VSS interconnects and integrates with the ACAMS, IDS, and security/emergency communications system such that alarms/events generated within the other systems (generally carried through the ACAMS) cause VSS and the VMS to behave in a programmed manner.
   a. Program active icons in graphic user interface map in the ACAMS to allow camera call up based on the selection of icon.

C. Video Surveillance System (VSS) Scope
1. Server (to host VMS software): The Owner will provide a server for the VMS software package.
2. Video Storage hardware / Network Video Recorder (NVR): The Owner will provide a server store video.
3. Video Management System Software: Provide VMS software package, including loading the VMS package onto the VMS server and integrating the software onto the network and integrating the video storage hardware into the VMS. Coordinate with the Owner’s IT department for network integration and other IP-related requirements. Provide VMS licenses in a quantity sufficient to support the project’s cameras and client workstations plus 20% (minimum, round up to nearest whole number).
4. Program the software system to meet the project requirements including programming recording input points, video call up, and other aspects of the system. Provide software interface to the ACAMS, IDS, and security/emergency communications system for alarm call up of cameras on predefined alarm events.
5. Provide cameras as shown on the drawings. Provide outdoor housing and mounts for exterior cameras.
6. Provide power supplies to supply power to cameras. Do not combine with ACAMS power supplies.

D. Tamper Monitoring: Provide one tamper switch within each PTZ dome enclosure to monitor the enclosure, including wiring, connection to ACAMS panel; and programming this tamper switch into ACAMS system as monitor input point.

E. Surge Protection: Regardless of who provides the cabling to outdoor cameras, ensure that the connection infrastructure for outdoor cameras receive proper protection against transient voltages. Installations shall comply with CEC 800.47, CEC800.50 and CEC 800.90.

F. Extra Materials
1. Furnish 10% spare parts of total installed the following (round up to the next complete device):
   a. Fixed cameras
   b. Power Supplies (specifically for VSS)
   c. Relays

1.5 SUBMITTALS

A. Contractor Qualifications: Submit certifications for the manufacturers of the video surveillance equipment.
B. Product Data: Submit product information for components specified herein.
C. Shop Drawings:
   1. Device placement on floor plans.
   2. Point-to-Point Diagrams: Include wiring, points of connection and interconnecting devices between the following:
      a. Video surveillance system, monitors, and recording equipment
      b. Devices connected to the system
      c. Miscellaneous control relays
      d. Conductors (identify conductors on the point-to-point diagrams with the same tag as the installed conductor)
   3. Camera Matrix: Submit as an Excel-compatible spreadsheet a matrix that includes each camera. The matrix, using the same ID as shown on the as-built drawings, shall include the following column headers, at a minimum:
      a. Device
      b. Device Identifier
c. Location
d. MAC Address
e. IP Address
f. IDF Room
g. Network Switch
h. Switch Port

4. Block Diagram/Riser Diagram: Show the video surveillance system components, conduit, wire types, and sizes between them, including cabling interties between termination hardware.
5. User interface graphics with icons and control buttons displayed.
6. Custom mounting details

D. Submittal Requirements at Closeout:
1. As-Built Drawings (this may be combined with the ACAMS as-built drawings): submit as-built drawings that includes block diagram, riser diagram, wiring diagram, and reflected ceiling plans, floor plans and site plans showing camera locations (tagged with a unique ID per camera).
2. Camera Matrix: submit as an Excel-compatible spreadsheet a matrix that includes each camera. The matrix, using the same ID as shown on the as-built drawings, shall include the following column headers, at a minimum:
   a. Camera Type
   b. Camera ID (shall match the as-built plans)
   c. Camera manufacturer and model (shall match the approved product data submittal)
   d. Camera lens manufacturer and model (shall match the approved product data submittal)
   e. Location
   f. MAC Address
g. IP Address
h. IDF Room
i. Network Switch
j. Switch Port
k. Maintenance requirements

3. O&M Manuals: submit O&M Manual as a binder or soft copy (bookmarked PDF) including the following, at a minimum:
   a. Product data – approved submittals ('cleaned up') and electronic
   b. As-built drawings, printed to 11x17 / tabloid landscape and electronic PDF files and native files (DWG or RVT) on storage media
   c. Warranty statement and service protocol (guidelines, contact numbers, etc.)
   d. Maintenance requirements
   e. Station Matrix, printed to 11x17 / tabloid landscape and electronic PDF files and native XLSX file on storage media
   f. Network switches and ports configuration information

1.6 WARRANTY

A. Warrant the system for a period of one year from the date of system acceptance. The warranty shall cover system operation/performance, parts, and labor. Correct deficiencies within 24 hours of notification.
PART 2 - PRODUCTS

2.1 CAMERAS

A. Fixed IP Corner Mount Camera
   1. Type: Color, vandal-resistant
   2. Power: PoE
   3. Image: 1/3-inch format, unless otherwise noted
   4. Lens Mount: Accept a "CS" mount auto or manual-iris lens
   5. Resolution: 1080p HD
   6. Minimum Light Level: 0.3 fc imager illumination at full video, unless otherwise noted
   7. Lens: 1.8mm, unless otherwise noted
   8. Frame Rate: 25fps at H.264
   9. Manufacturer, or equal:
      a. Axis #P9106-V

B. Fixed IP Interior Dome Camera
   1. Type: Color, vandal-resistant
   2. Power: PoE
   3. Image: 1/3-inch format, unless otherwise noted
   4. Lens Mount: Accept a "CS" mount auto or manual-iris lens
   5. Resolution: 1080p HD
   6. Minimum Light Level: 0.1 fc imager illumination at full video, unless otherwise noted
   7. Lens: 3 to 9mm, unless otherwise noted
   8. Frame Rate: 30fps at H.264
   9. Manufacturer, or equal:
      a. Axis #P3375-V
      b. Axis #T91D61
      c. Axis #T94K01D

C. Fixed IP Exterior Dome Camera
   1. Type: Color, vandal-resistant
   2. Power: PoE
   3. Image: 1/3-inch format, unless otherwise noted
   4. Lens Mount: Accept a "CS" mount auto or manual-iris lens
   5. Resolution: 1080p HD
   6. Minimum Light Level: 0.1 fc imager illumination at full video, unless otherwise noted
   7. Lens: 3 to 9 mm, unless otherwise noted
   8. Frame Rate: 30fps at H.264
   9. Manufacturer, or equal:
      a. Axis #P3375-VE
      b. Axis #T91D61
      c. Axis #T94M02D

D. Interior 360-Degree Camera
   1. Video Compression format: H.264, MPEG-4, MJPEG
   2. Power over Ethernet + (IEEE 802.3at)
   3. Resolution: 10240 x 1920 – 8 Megapixel
4. Frame Rate: 15 fps at 2MP (H.264)
5. Sensor: Four 1/2.8” progressive scan CMOS sensors
6. Vandal Resistant Dome
7. Type: Day/Night
8. Camera Manufacturer:
   a. Axis #P3707-PE
9. Accessories, or equal:
   a. Axis #T91D61
   b. Axis #T94M02D

E. Exterior 360-Degree Camera
1. Video Compression format: H.264, MPEG-4, MJPEG
2. Power over Ethernet (IEEE 802.3af, Class 3)
3. Resolution: 10240 x 1920 – 20 Megapixel
4. Frame Rate: 3.5fps at H.264
5. Sensor: Four 1/2-1/2” progressive scan CMOS sensors
6. Vandal Resistant Dome
7. Type: Day/Night
8. Manufacturer, or equal:
   a. Hanwha #PNM-9000VQ
9. Accessories, or equal:
   a. Hanwha #SBP-276HM
   b. Hanwha #SBP-390WM1
   c. Hanwha #SBP-300KM

F. Exterior 360-Degree Camera with IR
10. Video Compression format: H.264, MPEG-4, MJPEG
11. Power over Ethernet (IEEE 802.3af, Class 3)
12. Resolution: 4x2560x1440 – 15 Megapixel
13. Frame Rate: 3.5fps at H.264
14. Sensor: Four 1/2-1/2” progressive scan CMOS sensors
15. Vandal Resistant Dome
16. Type: Day/Night
17. Manufacturer, or equal:
   a. AXIS P3719-PLE
18. Accessories, or equal:
   a. T94N01D Pendant Kit
   b. T94N01L Recessed Mount

G. PTZ Network Camera
19. Video Compression format: H.264, MPEG-4, MJPEG
20. Power over Ethernet (IEEE 802.3af, Class 3)
21. Resolution: 1920 x 1080 – 2MP
22. Frame Rate: 30fps at H.264
23. Sensor: 4.44 Optical 32x lens
24. Type: Day/Night ICR
25. Manufacturer:
   a. Hanwha #PNM-9320VQP
26. Accessories, or equal:
a. SBP-300LM  
b. SBP-300CM  
c. SBP-300WM

2.2 VIDEO MANAGEMENT SOFTWARE

A. NVR Video Management Software
   1. Video surveillance software must have software integration with ACAMS. Hard-wired input/output alarms is not acceptable.
   2. Include software licenses:
      a. Camera licenses to support devices shown on project drawings
      b. Client workstation licenses to support a minimum of 5 concurrent users
      c. Internet Explorer client browser license
   3. Manufacturer:
      a. Salient Systems Complete View Enterprise (to match existing standard)

2.3 POWER SUPPLIES/BATTERY CHARGERS

A. VSS System Power Supplies
   1. 120 VAC input to 24 VAC output, continuous current, fully supervised power supplies for power to cameras.
   2. Provide a separate fused connection to power supply per camera.
   3. Exterior PTZ Camera, or equal:
      a. AXIS #5000-001 24VAC Outdoor power supply

2.4 LINE PROTECTORS

A. For use on data cables serving exterior cameras.
B. Manufacturer, or equal:
   1. Transectr #1101-994
   2. DITEK

2.5 IP VIDEO ENCODER

A. General
   1. Video Compression: Motion JPEG, MPEG-4 Part 2 (ISO/IEC 14496-3), Profiles: ASP and SP
   2. Resolution: 4CIF, 2CIFExp, 2CIF, QCIF
   3. Frame Rate: Up to 30/25 per channel
   4. Pan/Tilt/Zoom control
   5. Alarm and event management
   6. Channels: 4 minimum

B. Blade Video Server
   1. Hot-swappable
   2. Built-in, universal power supply
   3. Security: IP address filtering and HTTPS encryption
4. Manufacturer, or equal:
   a. Axis #243Q blade video server

C. Video Server Rack Enclosure
   1. High density rack-mount solution
   2. Capable of storing a minimum of 3 interchangeable and hot-swappable blade video servers
   3. Manufacturer, or equal:
      a. Axis #29 1U video server rack

PART 3 - EXECUTION

3.1 PRE-CONSTRUCTION PLANNING

A. Prior to the completion of construction, schedule a meeting with the Owner and the Engineer to determine the system programming requirements, such as the following:
   1. Camera naming/numbering
   2. Field of view per camera
   3. Settings for contrast, wide dynamic range, and auto-iris
   4. Camera call-up and recording features, including video motion detection

B. Camera Locations
   1. Prior to installation, coordinate/confirm camera locations. As needed, perform a field walk with the Owner. Obtain Owner signoff of camera locations and field of view per camera prior to installation.
   2. Prior to rough-in construction, coordinate rough-in locations and requirements per camera.

3.2 INSTALLATION

A. Cameras
   1. Field determine exact placement of cameras to ensure complete coverage.
   2. Field determine fixed camera lens size to ensure complete coverage.
   3. Provide outdoor housing and mounts for exterior cameras.
   4. For exterior cameras, provide LiquidTight flexible metallic conduit from junction box to camera housing and connect from below.
   5. Provide 25-foot cable loop at PTZ location for relocating unit if required post installation
   6. Coordinate Network Data Drop with Telecom contractor for each IP Camera.
   7. Coordinate camera IP address with District IT staff.

B. VSS Power supplies
   1. Do not combine with Access Control & Alarm Monitoring System power supplies.

C. Network Video Recorder Storage
1. Coordinate installation of additional camera licenses and programming of cameras on owner provided network video server with District ITS

D. Surge Protection
1. Provide surge protection for video, power, and control cable on exterior cameras.
2. Provide protective device at the camera and encoder/encoder device.

3.3 PROGRAMMING

A. Network Video Recorder
1. Connect the servers/storage to the Owner’s LAN/WAN to allow remote viewing from authorized workstations utilizing the VMS client viewing software. Configure the cameras and servers at the following initial requirements:
   a. Codec: H.264
   b. Resolution: 1080p (minimum)
   c. Storage: 30 Days (minimum)
   d. Recording: Motion
   e. Frame Rate: 15 fps

B. Document the results of the meeting and perform necessary programming to achieve the Owner’s requests.
C. Setup and program the system such that no additional programming required.
D. Use the camera naming convention agreed upon at in the programming meeting when programming point names into the system.
E. Perform two full system back-ups at completion of initial programming and deliver one copy to the Owner with a letter of transmittal explaining information included in back-up and brief description of recovery procedures. Perform back-ups on a regular bases through the remainder of the project.

3.4 TESTING

A. Test the video surveillance system in accordance with Section 28 08 00.

3.5 SYSTEM OPERATION CONFIRMATION

A. At 30 days after substantial completion, perform field review of video surveillance system software with the Owner to "fine tune" configuration settings for resolutions, recording, and frame rate to meet the storage and operational requirements.

END OF SECTION
SECTION 283100 - ANALOG ADDRESSABLE FIRE ALARM AND DETECTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire alarm system operation.
2. Fire alarm equipment.
3. Fire alarm wiring.

B. Provide an integrated, analog addressable, monitoring and control system for a complete fire alarm system as described herein. The system includes, but is not limited to, control units, power supplies, digital alarm communicating transmitter, remote annunciators, initiating devices, notification appliances, and outputs for specified fire life safety and control functions. The system also includes batteries, relays, fire alarm termination cabinets, conduit, wiring, and other equipment for a complete and operating system.

C. Unit Prices: Provide unit pricing for the following pieces of equipment. The unit pricing will include complete installation of devices listed with 40 feet of cable, conduit, if required, connections, programming, battery capacity, and the like.

1. Addition of manual pull station.
2. Addition of rate-or-rise or fixed temperature heat detector.
3. Addition of photoelectric or ionization smoke detector.
4. Duct mounted ionization or photoelectric smoke detector.
5. Magnetic door holder.
6. Speaker.
7. Audible/visible notification appliance.
8. Visible notification appliance.
9. Addressable relay with complete connection to item to be controlled or monitored.

1.2 SYSTEM DESCRIPTION

A. System Supervision: Provide electrically supervised, microprocessor-based system, with analog/addressable supervised two-wire Class B signaling line circuit and Class B notification circuit. Occurrence of single ground or open condition in initiating device, notification appliance, or signaling line circuit places circuit in "trouble" mode. Component or power supply failure places system in "trouble" mode. Fire sprinkler activation or duct-mounted smoke detector activation puts system in "supervisory" mode. Occurrence of single ground or open condition on alarm initiating circuit or on signaling circuit does not disable that circuit or control panel from transmitting "alarm." Each circuit includes individual supervisory and alarm function and is to be so arranged that a fault condition in circuits will not affect the proper operation of other circuits.

B. Alarm Sequence of Operation: Activation of a manual fire alarm box, automatic fire detector, or fire extinguishing system causes system to enter "alarm" mode including the following operations:

1. Provide local English language annunciation of device location, address and condition, and audible and visual alarm signal at control panel and remote annunciators.
2. Provide manual "acknowledge" function at control panel and remote annunciators to silence audible alarm signal, visual signal remains displayed until initiating alarm is cleared.
3. Transmit “alarm” signal to off-premises equipment, i.e., to the local fire department or Owner's selected vendor. Provide necessary connections to digital alarm communicator transmitter.
4. Activate fire alarm notification appliances.
5. Transmit signal to fire/smoke dampers.
6. Transmit signal to initiate shutdown of air handling equipment.
7. Transmit signal to release fire doors.
8. Transmit signals to elevator control equipment to initiate elevator recall and shunt trip.
9. Transmit signal to building access/security system.

C. Supervisory Sequence of Operation: Fire sprinkler tamper switch activation or duct-mounted smoke detector activation causes system to enter “supervisory” mode including the following operations:
1. Provide local English language annunciation of device location, address and condition, and audible and visual supervisory signal at control panel and remote annunciators.
2. Provide manual "acknowledge" function at control panel and remote annunciators to silence audible supervisory signal, visual signal remains displayed until initiating supervisory is cleared.
3. Transmit "supervisory" signal to off-premises equipment.

D. Trouble Sequence of Operation: System trouble, including single ground or open of supervised circuit, or power or system failure, causes system to enter “trouble” mode including the following operations:
1. Provide local English language annunciation of device location, address and condition, and audible and visual trouble signal at control panel and remote annunciators.
2. Provide manual "acknowledge" function at control panel and remote annunciators to silence audible trouble signal, visual signal remains displayed until initiating trouble is cleared.
3. Transmit "trouble" signal to off-premises equipment.

E. System Reset: Key-accessible control function returns the system to normal, non-alarm state, if initiating circuits have cleared. Reset to be located on both the main fire alarm control panel and the remote annunciators.

F. Lamp Test: Manual "lamp test" function causes the annunciation lamps to illuminate at fire alarm control and remote annunciator panels. Provide "lamp test" function at each annunciator panel.

G. Addressing: Provide each initiating device with its own discrete analog address.

H. Power Requirements:
1. The control panel receives 120VAC via a dedicated circuit per NFPA requirements.
2. Loss of normal and emergency power automatically causes the system to transfer to battery power. Indicate battery power operation by a yellow lamp and audible annunciation at the control panel and remote annunciator panels. Upon return of 120VAC power, unit recharges batteries to full capacity and maintains battery on float charge.
3. Provide storage batteries of sufficient capacity to operate the fire alarm system under normal supervisory condition for 24 hours and operate alarm signals for 15 minutes at the end of the standby period. Provide trickle charge adequate capacity to maintain the battery fully charged with automatic rate charge. Provide batteries in a locking cabinet manufactured for the purpose. Do not install cabinets or equipment below the battery cabinet. Do not locate battery and charging system cabinets in ceiling space.

1.3 SUBMITTALS

A. Submit shop drawings and product data in accordance with Division 01.
B. A maximum of two submittal reviews will be performed by the Engineer. Compensate additional time and material to the Engineer based on their published fees for additional reviews.

C. Equipment submittals must include the following:
   1. Complete descriptive data (cut sheets) including UL listing, FM approval (for the specified application) for system components.
   2. Provide Shop drawings to include the following:
      a. A symbol key with device catalog number, description, dimensions, back box size and mounting requirements.
      b. Detailed riser diagram.
      c. Device address and notification appliance circuit number with end-of-line device.
      d. Battery calculations for each battery backed fire alarm control unit.
      e. Voltage drop calculations for each notification appliance circuit, indicating conductor run length and size. 10 percent voltage drop maximum.
      f. Complete sequence of operation.
      g. Point to point wiring indicating the quantity and gauge of the conductors and size of conduit/raceway used.
      h. Wiring connection diagrams for components being connected to the system and interfaces to associated equipment.

D. Submit manufacturer's installation instructions.

E. Submit complete product data sheets and shop drawings to local AHJ, for approval, prior to construction.

F. Submit, prior to final acceptance, a letter confirming that inspections have been completed and the system is installed and functioning in accordance with the Specifications. Include manufacturer representative's certification of installation and letter of warranty.

G. Operation and Maintenance Manuals: Provide manuals containing cut sheets, manufacturer's operation and maintenance manual, troubleshooting guide, operating instructions, spare parts list, program printout, and data file on CD-ROM, 1 year warranty agreement including parts and labor, and professional Record Drawings. Warranty period begins upon the date of final acceptance.

1.4 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
   1. Installation subject to inspection and approval of federal, state and local authorities.
   2. Equipment: UL listed FM approved.
   3. Contact AHJ prior to bid and provide required fire alarm and detection devices and components as required by adopted codes as interpreted by AHJ.

B. Reference Standards:
   8. UL 864 Listing.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Furnish equipment specified in this Section by one manufacturer: Siemens XLS, XLSV or approved equal.

2.2 MATERIALS

A. Control panel:
   1. Multiprocessor Based: Configurable as an analog/addressable, point identified system.
   2. System will be capable of displaying the analog value of each smoke detector, the address and condition of fire alarm monitoring points.
   3. CPU continuously monitors the communications and data processing cycles of the microprocessor. On CPU failure the system generates an audible and visual trouble signal on the control panel and remote annunciators.
   4. House the CPU in the fire alarm cabinet with sufficient space to allow maximum system expansion and to enclose the alphanumeric display.
   5. Retain basic life safety software in field programmable non-volatile memory. Provide the CPU with a capacity of a minimum of 100 addressable points.
   6. The system is multichanneled. Each channel operates independently. Faults on one channel not impede operation of the other.
   7. Equip the CPU with software to provide a control-by-event feature, whereby the receipt of an alarm point is programmed to operate the control points within the system. Provide control-by-event actions for life safety functions in a programmable non-volatile memory. CPU software programming for control of systems defined in this Section is installed as a part of this Section. Reprogram the support system prior to acceptance, if required by Owner.
   8. System is capable of addressing and operating smoke detectors, manual pull stations, open contact devices and addressable auxiliary control relays on the same communication loop.
   9. Program Software:
      a. The field configuration program provides the programmable operating instructions for the system. Store the resident program in non-volatile memory.
      b. Perform the programming at the location of the fire alarm control panel. Program the system without shutting the system down. Programming is done off line. Update and maintain a hard copy and a CD-ROM copy of the program at the site. Make system programming software available to Owner, at an additional cost, allowing the user to reprogram system points, add system points, add or change point descriptions and update the data file.
      c. Programmed control point activation includes selective control of HVAC, door holder release, elevator recall, system equipment monitoring, and fire safety and auxiliary functions.
      d. Devices meet criterion specified under materials.
      e. Verification and display of sensitivity of each addressable smoke detector can be read using the operating software. Replace devices with readings outside of the allowed value at time of system check out.
   10. Control Panel Display Modules: Provide keyboard display module 80-character backlit LCD. Each alarm/trouble condition appears in English language with the description and location of the alarm/supervisory/trouble. The alarm/supervisory/trouble may be acknowledged, silenced and the system reset from the control panel or the remote annunciator(s).
   11. Power Supply: Provide power supply(s), adequate to serve control panel modules, remote annunciators, addressable devices, notification appliances, and other connected devices.
   12. Digital Alarm Communicator Transmitter (DACT): Electrically supervised, capable of transmitting alarm, supervisory and trouble signals over telephone lines to off-premises receiver. Signal transmitter interfaces fully with receiver station of local fire department or
Owner's selected vendor. Verify requirements and provide call sequence and message as directed by Owner and the AHJ.

13. Auxiliary Relays: Provide sufficient SPDT auxiliary relay contacts for each function in this portion of the Specifications and for equipment interconnections required under electrical and mechanical specifications.

14. Auxiliary Switches: Provide auxiliary equipment control switches with labeled status indicating lights for each switch.

B. Emergency Voice/Alarm Communications System Panel.

1. UL 864 listed.
2. Provide the fire protective signaling system circuits in accordance with Style Y for Notification Appliance Circuits (NAC). Open condition in circuit will cause trouble indication at control panel.
3. LED indicators for power trouble, ground trouble, and signal trouble in each NAC. Also, LED indicators for manual evacuation status, clear status, and "ready to talk" status for manual microphone paging.
4. Selectable audio tones (at least four different tone patterns) and voice message generation via digital recorded messages (either Owner supplied, from professionally recorded tapes or a manufacturer provided library).
5. Operator controls at panel include manual evacuation (alarm signal from momentary switch activation), manual clear from momentary switch activation, local microphone manual paging, remote microphone manual paging option.
6. Capable of receiving alarm signal from host panel notification appliance circuit.
7. Includes audio amplifier with a minimum capacity of 50 watt.
8. Built-in spoken diagnostic system testing program, permitting testing of individual speakers by one unassisted person.

C. Addressable Initiating Devices:

2. Fixed Temperature Heat Detectors: Rated 135F or 190F as noted on Drawings or required by space use. Provide off white low profile detectors.
3. Rate-of-Rise and Fixed Temperature Heat Detectors: Responding to 15F temperature rise per minute and to 135F fixed temperature as noted on Drawings or required by space use. Provide off white low profile detectors.
5. Ionization Type Analog Detector: Analog/addressable dual chamber 360 degree smoke entry, visual latching operation indicator, insect screen, panel adjustable sensitivity, test switch, tamper resistant and solid state voltage regulation.
6. Duct-Mounted Analog Smoke Detectors: Analog addressable, combination of ionization and photoelectric types, auxiliary relay contacts rated at 5 amps each at 120VAC. Duct sampling tubes extending width of duct, visual indication of detector actuation, direct housing mount. Detector powered from control panel, power on indicator light. Detector rated for air velocity, humidity, and temperature of duct. Provide with a remote LED/test switch.
7. Flame Detector: Encapsulated solid state electronic circuitry with auxiliary contacts. Visual alarm light, 3 second time delay, open area ultra violet 6 second response to 12-inch diameter hydrocarbon fire when viewed head-on from 30 feet. No response to sunlight or artificial light sources. Provide each detector with an addressable module.
8. Addressable Control Module: Signaling line circuit interface module that connects to notification appliance circuits and provides system control outputs. Module powered from control panel.
9. Addressable Monitor Module: Signaling line circuit interface module that connects to initiating devices and initiating device circuits. Module powered from control panel.

10. Remote Switches: Provide remote control/indication and test switches for system or equipment testing or control accompanied by English language labeled indicator lamps, i.e. for duct-mounted smoke detectors, projected beam type smoke detector, and the like.

11. Water Flow and Pressure Alarm Switches: Verify requirements, locations, and quantities with sprinkler design. Switches are provided by Division 15, wired by Division 16, unless specifically noted otherwise. Provide each switch with an addressable module.

12. Supervisory Pressure and Tamper Switches: Verify requirements, locations, and quantities with sprinkler design. Switches are provided by Division 15, wired by Division 16, unless specifically noted otherwise. Provide each switch with an addressable module.

13. Projected Beam Type Smoke Detector: Infrared emitter and receiver, adjustable reception threshold, micro processor self adjusting compensation for optic contamination, acrylic anti fog infrared filter, green power indicating LED, red alarm LED, and yellow trouble LED. Voltage and RF suppression, compensating circuitry for vibration and temporary obscuration. Auxiliary contacts. Provide each detector with an addressable module and a remote LED/test switch.

14. Wire Guards: Chrome steel guard. Provide where device is subject to abuse and where required by AHJ. Submit original, color, data cut sheets for approval by Architect.

15. Single/Multiple Station Smoke Alarm: 120VAC photoelectric smoke alarm/detector with 9VDC battery backup as an auxiliary power source in the event of an electrical failure. Include 90dB piezo solid-state, nonlatching horn. Temporal 3 evacuation sounding device. Tandem connection up to 12 units. Three-position test switch.

16. Single/Multiple Station Smoke Alarm with Strobe: 120VAC photoelectric smoke alarm/detector with 9VDC battery backup. Include 90dB piezo solid-state, nonlatching horn and 177 candela strobe. Add Alternate: Coordinate with Campus for Temporal 3 evacuation sounding device. Tandem connection up to six units. Three-position test switch.

D. Annunciators:

1. Alphanumeric Remote Annunciator with Controls: Back lit LCD alphanumeric annunciator 80 characters long. Provide under locking cover a test switch, alarm and trouble buzzer, buzzer silence switch and buzzer silence message and reset switch, flush mount with finished cover, vandal-resistant UV stabilized Lexan (or approved) overlay and required modules, control panel, etc., to drive annunciator. Self-contained, suitable for wet location where located exterior. Verify location with AHJ before installation.

2. Provide framed floor plan of facility adjacent to the annunciator panel identifying room names/numbers, device/addresses or fire zone number and listing as utilized on the annunciator panel, as required by local AHJ. Check with the local fire department for size and approved mounting location.

E. Door Hold-Opens/Closers, Elevator Recall, Fire/Smoke Damper Control, and Fire Safety and Auxiliary Functions:

1. Magnetic door holders. Provide smoke detection and addressable control relays to release magnetic hold open devices. Verify requirements and quantities prior to bidding.
   a. Magnetic hold open/closers installed by door hardware supplier. Division 16 provides power and control conduit, wiring, boxes and terminations to power devices and interface devices to fire alarm system.
   b. Hold door open until signaled by addressable relay module. When actuated, the device will release door to close. Doors release automatically on power failure.

2. Provide elevator recall smoke detectors, addressable control relays, and connection to elevator equipment per NFPA 72 and as required by the AHJ.

3. Provide elevator shunt trip heat detectors, addressable control relays, addressable monitor relay for shunt trip power, and connection to elevator equipment per NFPA 72 and as required by the AHJ.
4. Provide fire/smoke damper control/monitoring. Provide required smoke detectors, relays, wiring, and the like. Provide spot type smoke detector(s), listed for releasing service, and install within 5 feet of the dampers per the CBC or as required by the AHJ. Verify requirements, locations and quantities with Division 15 prior to bidding.

F. Notification Appliances:
   1. Speakers: Flush wall mount, white finish. Insect-proof 4-inch multitap to 1/4, 1/2, 1, and 2 watts with back box and trim grill. State of California fire marshal listed Provide speaker capable of transmitting tone or voice. Trim finish as directed by Architect. Provide with integral ADA and UL 1971 approved strobe light as required by AHJ. Candela rating as required per space used.
   2. Speaker/Strobe Appliances: Flush wall mount, white finish. Provide speaker capable of transmitting tone or voice. Provide with integral ANSI 117.1 and UL 1971 approved strobe light. Candela rating as required per space used.
   3. Audible/Visible Appliances (Horn/Strobes): Flush wall mount, white finish. Provide horn-strobes that meet the latest requirements of NFPA 72, ANSI 117.1 and UL 1971. Candela rating as required per space used.
   4. Visible Notification Appliances (Strobes): Flush wall mount, white finish. The strobes will meet or exceed the latest requirements of NFPA 72, ANSI 117.1, and UL standard 1971. Candela rating as required per space used.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Obtain approval of system design from AHJ prior to installation. Do not begin installation without approval from AHJ and submittal review comments from Engineer.

B. Terminate fire alarm conductors in control and annunciator panels on terminal strips. Connect wiring neatly and secure to cabinet with nylon cable straps. Set up termination of cabling so that sections of the system may be isolated or shorted out for servicing. Maximum of two conductors under each terminal strip connection.

C. From fire alarm controlled relays, make connection to motor controls and related equipment as required for fan system control. Provide relays UL listed for the purpose.

D. Wiring:
   1. In accordance with manufacturer's instructions, provide wiring, conduit and outlet boxes required for the erection of a complete system as described herein, as shown on Drawings, and as required by AHJ.
   2. Provide wiring to meet the requirements of national, state and local electrical codes. Provide color coded wiring as recommended and specified by the fire alarm and detection system manufacturer. Minimum signaling line circuit and initiating device circuit wire size: AWG 18. Minimum notification appliance circuit wire size: AWG 14, or as approved by the Engineer. Test wiring free from ground faults and short circuits.
   3. Provide complete conduit system for wiring. Provide Type FPL power-limited fire alarm cable. Provide Type FPL power-limited fire alarm cable when run open or in raceway. Type FPLR power-limited fire alarm cable when run is from floor to floor or in a vertical run in a shaft (install raceway where passing through a floor to a height of 7 feet above the floor) and Type FPLP power-limited cable when wiring is in ducts or plenum space.
   4. Provide final connections between equipment and the wiring system approved by manufacturer.
   5. At junction boxes and termination points, provide identification tags on wires and cables.
E. Duct-Mounted Smoke Detectors:
1. Provide duct-mounted smoke detectors on air systems with air quantities of 2000 cfm or more. Coordinate with Division 15.
2. Install duct-mounted smoke detector(s) on supply or return side of air duct. Coordinate with campus for final location.
3. Provide control wiring from duct-mounted detector auxiliary relay contacts to air handling equipment controller. Connect to controller so that when duct-mounted smoke detector is activated, the air handling equipment is shut down.
4. Provide duct-mounted smoke detectors rated for air velocity, temperature, and humidity of duct. Verify quantities, locations, and requirements with Division 15 Drawings and mechanical system installer.
5. Where duct-mounted smoke detectors are mounted in inaccessible building void spaces provide access hatch. Provide access hatch with fire rating equivalent to rating of wall, ceiling, or shaft being penetrated.

F. Fire/Smoke Dampers and Smoke Dampers:
1. Connect control and power wiring to dampers per manufacturer's instructions.
2. Verify quantities, location and requirements of dampers with Division 15 Drawings and Specifications, and mechanical system installer.
3. For each fan unit serving fire/smoke dampers and smoke/dampers with associated duct-mounted smoke detectors, provide current sensing switch with 8-amp, 250-volt rated relay contacts (Hawkeye 740 series or approved) for cutting power to fire/smoke dampers when fan unit shuts down.
4. If damper is installed within a duct, provide smoke detector within 5 feet of damper with no air inlets or outlets between the damper and detector.
5. If damper is installed within an unducted opening, provide smoke detector located within a 5-foot horizontal radius of the damper to control the damper.
6. Provide control wiring, transformers and power connections for an operable damper and detection system.

3.2 FIELD QUALITY CONTROL

A. Upon completion of the installation, subject the system to operational tests and when necessary corrections have been accomplished, advise Architect who will schedule a final inspection test with the Owner. Ensure the connections to the fire alarm system have been in service for at least 10 days of trouble/alarm free operation prior to the final inspection. Furnish instruments, labor and materials required for the tests and a qualified technician to conduct the tests. Correct deficiencies found at no cost and retest system as necessary, prior to final acceptance. Tests include the following:
1. Operation of each signal initiating device (smoke detectors, heat detectors, pull stations, fire/smoke rated doors, process and facilities control sequences).
2. Operation of each notification appliance (alarm horn and alarm strobe).
3. Operation of features of the system under normal operation.
4. Operation of supervisory features of the system.
5. Operation of features of the systems on standby power with primary power off.
6. Documentation by download of control panel memory.

B. Upon completion of the installation of fire alarm equipment, provide to Architect a signed, written statement substantially in the form as follows: "The undersigned having been engaged as the Contractor on the facility confirms that the fire alarm equipment was installed in accordance with the Drawings, Specifications, wiring diagrams, instructions, directions provided by manufacturer, and requirements of the governing authorities."
3.3 EQUIPMENT DEMONSTRATION AND PERSONNEL TRAINING

A. At the direction of Architect the equipment supplier of the system will provide factory trained representative to demonstrate the operation of the fire alarm system equipment and to instruct the Owner's personnel in its operation. Provide names and date of instruction prior to final acceptance.

3.4 OPERATION AND MAINTENANCE MANUALS

A. Provide three sets of manuals to the Architect prior to final acceptance. Provide manuals containing professional developed Record Drawings, battery type and battery calculations, spare parts list, operating procedures, troubleshooting guide, program printout, data file on CD-ROM and a 1 year warranty agreement including parts and labor. Warranty period begins upon the date of final acceptance.

END OF SECTION
SECTION 310413 - COMMON SUBMITTAL REQUIREMENTS FOR EARTHWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER’S AND GENERAL CONTRACTOR’S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect’s staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect’s notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

   1. Action Code for Information Only:
      a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.

   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.

   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition

   1. Each submittal consists of items from only ONE Specifications section.
2. **Complete Submittal:** If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. **Partial Submittals:** If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. **All items in each submittal, whether complete or partial, will be processed together:** Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. **Submittal Numbering**

1. Number submittals as described below to assist tracking.

2. **Number each submittal in the format nnnnnn-nn.**

   a. **The 6-digit number is the number of the section that requires the submittal.** For example, 044200.

   b. **The 2-digit number is based on the numerical sequence of submittals from that section.** In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.

   c. **P-Number for Partial Submittals:** Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.

   d. **R-Number for Re-submittals:** Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.

   e. **Examples:**


3.4 **SUBMITTAL REVIEW SHEET REQUIREMENTS**

A. **Provide Submittal Review Sheet in PDF format.** Submit as the page after the Submittal Transmittal.

B. **When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.**

C. **Do not edit any of the information contained within the Submittal Review Sheet except as follows:**

   1. **Submittal Number:** See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. **The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.**
SECTION 311001 - PLANT PROTECTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Preserve and protect existing trees, shrubs and other plant materials to remain, including protecting plants on adjoining properties during site preparation work and construction.

B. Provide tree and shrub pruning and removal in accordance with these Specifications if required by the Contract Documents.

C. Layout and review of utility and irrigation trenches that occur in the Tree Protection Root Zone.

D. Related Requirements:
   1. Section 311200, SOIL STRIPING & STOCKPILING
   2. Section 312300, EXCAVATION & FILL
   3. Section 329000, PLANTING

1.2 QUALITY ASSURANCE

A. Reference Standards:
   1. Ordinances and Regulations: All local, municipal and state laws, codes and regulations governing or relating to all portions of this work are hereby incorporated into and made a part of these Specifications. Anything contained in these Specifications shall not be construed to conflict with any of the above codes, regulations or requirements of the same. However, when these Specifications and Drawings call for or describe materials, workmanship or construction of a better quality, higher standard than is required by the above mentioned codes and regulations, the provisions of these Specifications and Drawings shall take precedence. Furnish without extra charge additional materials and labor required to comply with above rules and regulations.

B. Pre-installation Conference:
   1. Conduct conference at the project site. Contractor shall review and identify with the District's Representative the limits of Work and extent of plant materials and other improvements to be protected. Notify District's Representative of discrepancies between existing conditions and Drawings before proceeding with Work.
   2. Review methods and procedures related to temporary tree and plant protection including, but not limited to, the following:
      a. Tree-service firm's personnel, and equipment needed
      b. Arborist's responsibilities.
      c. Quality-control program.
      d. Coordination of Work and equipment movement with the locations of protection zones.
      e. Trenching by hand or with air spade within protection zones.

C. At the District's discretion, an Arborist may represent the District to review the work of the Contractor in regards to plant protection. Arborist Qualifications: ISA Certified Arborist licensed to work in the State of California.
D. Tree Service Firm Qualifications: An experienced tree service firm that has successfully completed temporary tree and plant protection work similar to that required for this Project and that will assign an experienced, qualified arborist to Project site during execution of the Work.

1.3 PROJECT CONDITIONS

A. Coordination: Coordinate this work with the work of other Sections to avoid delay and interference with other work.

B. Nuisances: Keep dirt, dust, noise and other objectionable nuisance to a minimum. Use temporary enclosures, coverings and sprinkling, and combinations thereof, as necessary to limit dust to lowest practicable level, except do not use water to the extent that it causes flooding or contaminated run-off.

C. Traffic: Conduct work to ensure minimum interference with vehicular and pedestrian traffic, and to permit unencumbered access to site and adjacent properties.
   1. Do not close or obstruct streets, sidewalks, alleys or other public passageways without permission from authorities having jurisdiction.
   2. If required by governing authorities, provide alternate routes around closed and obstructed traffic ways.

D. The following practices are prohibited within protection zones:
   1. Storage of construction materials, debris, or excavated material.
   2. Moving or parking vehicles or equipment.
   3. Foot traffic.
   4. Erection of sheds or structures.
   5. Impoundment of water.
   6. Excavation or other digging unless otherwise indicated.
   7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

E. Do not direct vehicle or equipment exhaust toward protection zones.

F. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones and organic mulch.

1.4 DEFINITIONS

A. Diameter breast height (DBH): diameter of a trunk as measured at a height 54 inches above the ground line.

B. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction and indicated on Drawings.

C. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and as identified on the drawings or otherwise by a certified arborist.

D. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

E. Structural Root Zone: A circular area with the tree trunk at the center and a radius equal to 3 times the diameter of the tree trunk measured at breast height (4.5 feet above ground line).
This zone, where most of the structural roots exist, is based upon tree failure research conducted by E.T. Smiley at the Bartlett Tree Research Laboratory. Any structural (buttress) root, which has been severed or is rotten within this zone, can no longer provide adequate support to the tree and must be considered missing.

F. Dripline: The area of the ground directly beneath the vertical projection (shadow) of the trees foliage canopy.

1.5 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Include plans and locations of protection-zone fencing and signage, showing relation of equipment-movement routes and material storage locations with protection zones. Indicate extent of trenching by hand or with air spade within protection zones.
   2. Protection-Zone Signage

C. Qualification Data: For arborist and tree service firm.

D. Certification: From arborist, certifying that trees indicated to remain have been protected during construction according to recognized standards and that trees were promptly and properly treated and repaired when damaged.

E. Maintenance Recommendations: From arborist, for care and protection of trees affected by construction during and after completing the Work.

F. Survey of Existing Conditions: Provide to District a Survey of Existing Conditions. Record existing conditions, including underground utilities, etc. on As Built Drawings by use of field measurements and preconstruction photographs. Make permanent record of measurements, materials, and construction details required to make exact reproduction.

G. Tree Pruning Schedule: Written schedule detailing scope and extent of pruning of trees to remain that interfere with or are affected by construction.
   1. Species and size of tree.
   2. Location on site plan. Include unique identifier for each.
   3. Reason for pruning.
   4. Description of pruning to be performed.
   5. Description of maintenance following pruning.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Backfill Soil: Approved planting soil of suitable moisture content and granular texture for placing around tree; free of stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth.
B. Organic Mulch: Free from deleterious materials and suitable as a top dressing for trees and shrubs, consisting of one of the following:
   1. Type: Wood and bark chips
   2. Size Range: ½'-2”

C. Protection-Zone Fencing: Fencing fixed in position and meeting the following requirements:
   1. Chain-Link Protection-Zone Fencing: Galvanized-steel fencing fabricated from minimum 2-inch opening, 0.148-inch- diameter wire chain-link fabric; with pipe posts, minimum 2-3/8-inch- OD line posts, and 2-7/8-inch- OD corner and pull posts; with 1-5/8-inch- OD top and bottom rails; with tie wires, hog ring ties, and other accessories for a complete fence system.
      a. Height: 72 inches
   2. Gates: Swing access gates matching material and appearance of fencing, to allow for maintenance activities within protection zones.

D. Protection-Zone Signage: Shop-fabricated, rigid plastic or metal sheet with attachment holes prepunched and reinforced; legibly printed with nonfading lettering and as follows:
   1. Text: “Tree Protection Zone. No Heavy Equipment.”
   2. Lettering: 3-inch- high minimum, black characters on white background.

E. Tree Branch & Trunk Protection: for branches trunks exposed to, or at risk of exposure to impact by construction equipment.
   1. 2x lumber
   2. 1/2”-wide steel straps

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas in which work is to be performed. Report in writing to the District's Representative all prevailing conditions that will adversely affect the existing plant materials to remain. Do not proceed with work until a solution acceptable to the District’s Representative has been arrived at.

B. Survey of Existing Conditions: Record existing conditions, including underground utilities, etc. by use of measured drawings and preconstruction photographs.

C. Starting work constitutes acceptance of the existing conditions and the Contractor shall then, at his expense, be responsible for correcting all unsatisfactory and defective work encountered.

3.2 PREPARATION

A. Locate and clearly identify trees, shrubs, and other vegetation to remain an/or relocated. Tie a 1-inch blue vinyl tape around each tree trunk at 54 inches above the ground.
B. Protect tree root systems from damage caused by runoff or spillage of noxious materials while mixing, placing, or storing construction materials. Protect root systems from ponding, eroding, or excessive wetting caused by dewatering operations.

C. Tree-Protection Zones: Mulch areas inside tree-protection zones and other areas indicated. Do not exceed indicated thickness of mulch.
   1. Apply 4-inch uniform thickness of organic mulch unless otherwise indicated. Do not place mulch within 6 inches of tree trunks.

D. Install and maintain temporary fencing and other required protective devices and exclude construction activities from tree/shrub zones except as supervised by the Arborist / District's Representative.

E. If tree/plant protection zones cannot be protected with fencing, a four inch layer of mulch with minimum 1.25 inch thick, metal strap linked plywood shielding shall be maintained in the tree/shrub zone where heavy equipment will be operated.

3.3 PROTECTION ZONES

A. Protect trees and shrubs against cutting, breaking, skinning and bruising of bark; permit no traffic or stockpiling within drip line.

B. Do not change earth surface within drip line of trees and shrubs except as approved in writing by the Owner.

C. Do not park vehicles or store materials, supplies and construction equipment within Tree Protection Zone.

D. Verify details of protection-zone fencing before retaining last option in "Protection-Zone Fencing" Paragraph below.

E. Protection-Zone Fencing: Install protection-zone fencing along edges of protection zones before materials or equipment are brought on the site and construction operations begin in a manner that will prevent people from easily entering protected areas except by entrance gates. Construct fencing so as not to obstruct safe passage or visibility at vehicle intersections where fencing is located adjacent to pedestrian walkways or in close proximity to street intersections, drives, or other vehicular circulation.
   1. Chain-Link Fencing: Install to comply with ASTM F 567 and with manufacturer's written instructions.
   2. Posts: Set or drive posts into ground one-third the total height of the fence without concrete footings. Where a post is located on existing paving or concrete to remain, provide appropriate means of post support acceptable to District. Post may be steel driven type, or self-supporting type.
   3. Access Gates: Install where required; adjust to operate smoothly, easily, and quietly; free of binding, warp, excessive deflection, distortion, nonalignment, displacement, disruption, or malfunction throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

F. Protection-Zone Signage: Install protection-zone signage in visibly prominent locations in a manner approved by District. Install one sign spaced approximately every 20 feet on protection-zone fencing, with signs each facing a different direction.
G. Where tree branches & trunks are exposed to, or at risk of exposure to impact by construction equipment, secure 2x lumber radially around tree branches and/or trunk to prevent damage. Secure lumber with steel strapping.

H. Maintain protection zones free of weeds and trash.

I. Maintain protection-zone fencing and signage in good condition as acceptable to District and remove when construction operations are complete and equipment has been removed from the site.
   1. Do not remove protection-zone fencing, even temporarily, to allow deliveries or equipment access through the protection zone.
   2. Temporary access is permitted subject to preapproval in writing by arborist if a root buffer effective against soil compaction is constructed as directed by arborist. Maintain root buffer so long as access is permitted.

3.4 EXCAVATION & TRENCHING

A. General: Excavate at edge of protection zones and for trenches indicated within protection zones according to requirements in Section 312300 "Excavation" unless otherwise indicated.

B. Trenching within Protection Zones: Where utility trenches are required within protection zones, excavate under or around tree roots by hand or with air spade, or tunnel under the roots by drilling, auger boring, or pipe jacking. Do not cut main lateral tree roots or taproots; cut only smaller roots that interfere with installation of utilities. Cut roots as required for root pruning. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots.

C. Redirect roots in backfill areas where possible. If encountering large, main lateral roots, expose roots beyond excavation limits as required to bend and redirect them without breaking. If encountered immediately adjacent to location of new construction and redirection is not practical, cut roots approximately 3 inches (75 mm) back from new construction and as required for root pruning.

D. Do not allow exposed roots to dry out before placing permanent backfill. Provide temporary earth cover or pack with peat moss and wrap with burlap. Water and maintain in a moist condition. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.

3.5 ROOT PRUNING

A. Prune tree roots that are affected by temporary and permanent construction. Prune roots as approved by certified arborist.
   1. Generally cutting of roots two inches or greater shall be avoided. Roots one inch and greater in diameter that must be cut shall be cut cleanly and obliquely with the cut surface facing down.
   2. Exposed and pruned roots shall be covered with light well-drained soil backfill and mulch over. The area shall be kept moist.
   3. Cut roots manually by digging a trench and cutting exposed roots with sharp pruning instruments; do not break, tear, chop, or slant the cuts. Do not use a backhoe or other equipment that rips, tears, or pulls roots.
   4. Cut Ends: Do not paint cut root ends
5. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
6. Cover exposed roots with burlap and water regularly.
7. Backfill as soon as possible according to requirements in Section 312300 "Excavation."

B. Root Pruning at Edge of Protection Zone: Prune tree roots 6 inches outside of the protection zone by cleanly cutting all roots to the depth of the required excavation.

C. Root Pruning within Protection Zone: Clear and excavate by hand or with air spade to the depth of the required excavation to minimize damage to tree root systems. If excavating by hand, use narrow-tine spading forks to comb soil to expose roots. Cleanly cut roots as close to excavation as possible.

3.6 AIR SPADING:

A. Air spading, or hand removal of soil or tunneling is required for excavation in the Tree Protection Zone of any trees for the installation of infrastructure where roots 2 inches in diameter and larger are encountered. The "critical root zone" is defined as any area around a tree in which a two inch diameter root is encountered. The Arborist / District's Representative shall define the critical root zone and the Contractor shall excavate using a pneumatic excavator (AIR-SPADE or equivalent) as follows:

B. Trenching for utility lines or other infrastructure may be done mechanically outside the Tree Protection Zone. As the equipment operator approaches the canopy radius, or for certain species up to 1.5 times the canopy radius out from the base of the tree (Oaks, Poplars, Redwoods, etc.) the operator shall be assisted by a spotter who shall inspect the excavation for roots. If a root of two inches diameter is encountered the spotter shall halt mechanical excavation and pneumatic excavation shall proceed. If no other two inch or greater diameter root is encountered in an excavation of two feet forward and two feet deep, the single two inch root may be cleanly cut proximal to (on the tree side of) any fracture or torn bark. Mechanical excavation may continue until a two inch diameter root is encountered, and the pneumatic excavation, exploration is then repeated.

C. The Contractor shall control dust and the spread of soils excavated. The air-spade operator shall moisten the soil to field capacity and to a minimum probe depth of 2.5 feet with a watering needle (hydro-spear) 48 hours prior to pneumatic excavation. The spread of excavated soil shall be contained to the area adjacent to the trench path with upright plywood sheeting.

D. These specifications shall not be considered operating instructions or a requirement to use a specific pneumatic excavation product. It is the responsibility of the Contractor to read and understand the pneumatic excavator operation instructions and safety procedures (including the proper and safe use of air compressor, hoses, excavation tools, etc.) prior to operations.

3.7 TREE PRUNING

A. Obtain specific instruction from Arborist / District's Representative for pruning of trees, shrubs, roots or disturbance of soil within spread of tree branches. The Contractor shall utilize protection measures as outlined by Arborist / District's Representative, which may include directional drilling, or hand clearing to expose the roots.
B. Provide periodic watering for all planting within Contract limit and any adjacent areas affected by the work. Maintain moisture to a minimum 6" depth, minimum.

C. Using an approved pruning saw, provide selective tree limb pruning as accepted by the District if branches interfere with new construction. Limb diameter shall be limited to 5" diameter and shall be pruned just outside the branch collar in accordance with American National Standards Institute, (ANSI 300) and International Society of Arboriculture, (ISA) standards.

D. Approved branches to be shortened must be cut just above a fork with another living branch which is plus or minus 1/2 the diameter of the removed branch as shown in the pruning figure herein. Branches to be removed which exceed 2" in diameter shall be severed with a 3-step cut to prevent bark peeling. Final cuts must not injure the branch collar or branch bark ridge of the remaining branches and trunk.
E. Prune branches that are affected by temporary and permanent construction.
1. Prune to remove only injured, broken, dying, or dead branches unless otherwise indicated. Do not prune for shape unless otherwise indicated.
2. Do not remove or reduce living branches to compensate for root loss caused by damaging or cutting root system.
3. Pruning Standards: Prune trees according to ANSI A300 (Part 1)

F. Unless otherwise directed by arborist and acceptable to District do not cut tree leaders.

G. Cut branches with sharp pruning instruments; do not break or chop.
H. Do not paint or apply sealants to wounds.
I. Provide subsequent maintenance pruning during Contract period as recommended by arborist.
J. Chip removed branches and stockpile in areas approved by District.

3.8 REGRADING
A. Lowering Grade: Where new finish grade is indicated below existing grade around trees, slope grade beyond the protection zone. Maintain existing grades within the protection zone.
B. Lowering Grade within Protection Zone: Where new finish grade is indicated below existing grade around trees, slope grade away from trees as recommended by arborist unless otherwise indicated.
   1. Root Pruning: Prune tree roots exposed by lowering the grade. Do not cut main lateral roots or taproots; cut only smaller roots. Cut roots as required for root pruning.
C. Raising Grade: Where new finish grade is indicated above existing grade around trees, slope grade beyond the protection zone. Maintain existing grades within the protection zone.
D. Minor Fill within Protection Zone: Where existing grade is 6 inches or less below elevation of finish grade, fill with backfill soil. Place backfill soil in a single uncompacted layer and hand grade to required finish elevations.

3.9 FIELD QUALITY CONTROL
A. Inspections: Engage a qualified arborist to direct plant-protection measures in the vicinity of trees, shrubs, and other vegetation indicated to remain and to prepare inspection reports.

3.10 TREE & PLANT REMOVAL & REPLACEMENT
A. Field Verification: Before removing non-designated trees, shrubs, stumps, bushes, vines, rubbish, undergrowth and deadwood as shown on the Drawings and as specified, obtain verification from Owner's Representative.
B. Repair or replace trees, shrubs, and other vegetation indicated to remain or to be relocated that are damaged by construction operations, in a manner approved by District.
   1. Submit details of proposed pruning and repairs.
   2. Perform repairs of damaged trunks, branches, and roots within 24 hours according to arborist's written instructions.
   3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by District.
C. Backfill and compact areas excavated and open pits and holes resulting from removal operations. Comply with requirements herein and as specified in Section 312333 "Utility Trenching and Backfilling" for backfill materials, compaction and installation methods.
D. Remove all stumps and roots in their entirety. Tree trunks shall be removed minimum depth of 2 1/2 feet below existing grade or finish grade, whichever is deeper. Stump grinding is an acceptable method of removal of roots and stumps of trees and shrubs; however, the chip
contaminated soil shall be replace with approved clean planting soil in planting areas and with approved clean fill soil in all other areas.

E. Backfill and compact voids excavated and open pits and holes resulting from removal operations. Comply with Earthwork Specification for backfill materials, compaction and installation methods. Unless required otherwise, in planting areas backfill holes with clean approved planting soil compacted to 90% relative compaction to a minus 12 inches below finish grade and 85% relative compaction for the top 12 inches, except as required elsewhere to a greater degree by Civil or Structural Engineer. In non-planting areas backfill holes with approved fill soil compacted to 95% relative compaction.

F. Remove and replace trees indicated to remain that are more than 25% dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that District determines are incapable of restoring to normal growth pattern.

G. Plant Replacement: Contractor shall replace trees cut or severely damaged due to the Contractor’s work as follows:
   1. An ISA Certified Arborist may be retained by the District to determine the condition of trees in question as to their ability to survive in a healthy condition and in their original shape, or a pruned aesthetically pleasing shape acceptable to the District. Comply with recommendations to rehabilitate as recommended by the Arborist, or to replace in accordance with the requirements below.
   2. Trees size shall be determined by Diameter at Breast Height (DBH). Replacement of trees and shrubs shall also include providing acceptable plant installation, automatic irrigation system and a minimum maintenance period of 120 days. If plant(s) is not acceptably maintained and is not healthy and thriving at the end of the 120 day maintenance period, the Contractor shall continue the maintenance work until such time that healthy tree(s) and/or shrub(s) is achieved.
   3. Replace any damaged planting in kind using "specimen" plants as follows and at no cost to Owner:
      a. Trees up to 3” DBH: Replace with 36” box size.
      b. Trees 3” to 6” DBH: Replace with 72” box size.
      c. Trees 6” to 12” DBH: Replace with 84” box size.
      d. Trees 12” DBH and larger: Tree value shall be determined by Arborist using Council of Tree and Landscape Appraisers (CTLA) method. Replace damaged tree with largest available nursery boxed tree and cash difference between value of damaged tree and nursery stock replacement cost.
      e. Shrubs: Replace with 15-gallon can size.
   4. Plant and maintain new trees as specified

H. Excess Mulch: Rake mulched area within protection zones, being careful not to injure roots. Rake to loosen and remove mulch that exceeds a 3-inch uniform thickness to remain.

I. Soil Aeration: Where directed by arborist, aerate surface soil compacted during construction. Aerate 10 feet beyond drip line and no closer than 36 inches to tree trunk. Drill 2-inch- diameter holes a minimum of 12 inches (300 mm) deep at 24 inches o.c. Backfill holes with an equal mix of augered soil and sand.

3.11 CLEANUP AND DISPOSAL, per the District’s General Conditions.

A. Disposal: Remove excess excavated material, displaced trees, trash, and debris and legally dispose of them off Owner's property.
B. Clean excess soil may be distributed on site as accepted by District's Representative, if it does not adversely affect specified finish grades or percolation of water into planting soil.

C. Upon completion of work under this Section, remove all tools, equipment and temporary protections, enclosures and structures.

END OF SECTION
SECTION 311100 - CLEARING & GRUBBING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes all work necessary to successfully complete demolition, clearing & grubbing to prepare site for the phasing and new construction, including the following:
   1. Protecting existing trees and vegetation to remain.
   2. Trimming tree limbs and roots.
   3. Removing trees as designated.
   4. Clearing vegetation, debris, trash and other materials within limits indicated.
   5. Grubbing of vegetation within limits indicated.
   7. Removing above-grade site improvements within limits indicated.
   8. Disconnecting, capping or sealing, and abandoning site utilities in place.
   9. Disconnecting, capping or sealing, and removing site utilities.
  10. Disposing of objectionable material off site.
  11. Clean line saw cutting of existing asphalt pavement, concrete sidewalks, concrete curb/gutter, etc., as specified herein.
  13. Protection from injury or defacement of trees and other vegetation and objects to be preserved.
      a. Removal of surface debris and deleterious materials such as rubbish.
      b. Removal and stockpile of materials for landscaping use at approved location.
      c. Disposal of unwanted materials off site.

1.2 REGULATORY REQUIREMENTS

A. No burning shall be allowed.

B. Comply with the following California Code of Regulations:
   1. Title 8: CAL/OSHA, Chapter, Subchapter 4 – Construction Safety Orders
   2. Title 24: Part 2, California Building Code, Chapter 33, Protection of Pedestrian during Construction or Demolition.
   3. Bay Area Air Quality Management District

1.3 DEFINITIONS


B. CAL-OSHA: California Occupational Safety and Health Administration.

C. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2-inches in diameter; and free of weeds, roots, and other deleterious materials.
D. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.4 MATERIAL OWNERSHIP

A. Except for stripped topsoil or other materials indicated to remain District’s property, cleared materials shall become Contractor’s property and shall be removed from Project site.

1.5 SUBMITTALS

A. Follow Submittal procedure outlined in Division 0 – General Conditions and Division 1 – General Requirements.

1.6 PROJECT CONDITIONS

A. Except for materials indicated to be stockpiled or to remain the District’s property, cleared materials are the Contractor’s property. Remove cleared materials from site and dispose of in lawful manner.

B. Salvageable Improvements: Carefully remove items indicated to be salvaged and store where indicated on plans or where designated by the District. Avoid damaging materials designated for salvage.

C. Unidentified Materials;

1. If unidentified materials are discovered, including hazardous materials that will require additional removal other than is required by the Contract Documents, immediately report the discovery to the District.

2. If necessary, the District will arrange for any testing or analysis of the discovered materials and will provide instructions regarding the removal and disposal of the unidentified materials.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. Backfill excavations resulting from demolition operations with on-site or import materials conforming to structural backfill defined in Section 31 23 33 Utility Trenching and Backfill.

1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points during construction.
B. Locate and clearly flag trees and vegetation to remain or to be relocated.

C. Protect existing site improvements to remain during construction.
   1. Restore damaged improvements to their original condition, as acceptable to the District. Prior to restoration the contractor shall notify the District of the damaged improvements.

3.2 TREE REMOVAL

A. Remove trees designated for removal prior to the construction of new improvements.

B. Perform tree removal work in a safe and proper manner, adhering to CAL-OSHA and ANSI Standards.

C. Remove or grind stumps to a minimum of 18-inches below finish subgrade. Remove surface roots to this depth within 24-inches of the tree trunk. Trees, plants and roots that are below proposed building footprint or slabs on grade shall be removed in its entirety.

3.3 RESTORATION

A. Restore damaged improvements to their original condition, as acceptable to the District.

B. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, as directed by the District.
   1. Employ a qualified arborist, licensed in jurisdiction where the Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
   2. Replace trees that cannot be repaired and restored to full-growth status, as determined by the District. Clear and grub existing areas only to extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations.

3.4 BACKFILL

A. Place and compact material in excavations and depressions remaining after site clearing in conformance with Section 312333.

3.5 DISPOSAL

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials, including trash and debris, and legally dispose of them off the District’s property.

3.6 CONSTRUCTION WASTE MANAGEMENT

A. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the General Contractor’s Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

END OF SECTION
SECTION 311200 - SOIL STRIPPING & STOCKPILING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Removing existing vegetation.
   2. Clearing and grubbing.
   3. Stripping and stockpiling topsoil.

B. Related Requirements:
   1. Section 311001, PLANT PROTECTION
   2. Section 312300, EXCAVATION & FILL

1.2 DEFINITIONS

A. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil," but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects larger than 2 inches (50 mm) in diameter; and free of weeds, roots, toxic materials, or other nonsoil materials.

D. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction and indicated on Drawings.

E. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and indicated according to requirements in Section 31 10 01 “Plant Protection.”

F. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site to review extent of area where topsoil is to be stripped and stockpiled

1.4 MATERIAL OWNERSHIP

A. Except for materials indicated to be stockpiled or otherwise remain District's property, cleared materials shall become Contractor's property and shall be removed from Project site.
1.5 SUBMITTALS

A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
   1. Use sufficiently detailed photographs or video recordings.
   2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plant designated to remain.

B. Topsoil stripping and stockpiling program. Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

C. Soil Stockpile Quantity Report:
   1. Provide a written report documenting the quantity, location and height of all stockpiled soil.

D. Soil Analysis Report:
   1. Provide soil analysis report for each topsoil stockpile. Soils analysis report to be performed by Waypoint Analytical, a certified soil analysis laboratory, and include agricultural suitability analysis and recommendations for amending the soil. Subsoil will not be approved as planting soil.

1.6 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from District and authorities having jurisdiction.
   2. Provide alternate routes around closed or obstructed trafficways if required by District or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining District's property will be obtained by District before award of Contract.
   1. Do not proceed with work on adjoining property until directed by District.

C. Utility Locator Service: Notify utility locator service. Call Before You Dig for area where Project is located before site clearing.

D. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant- and tree-protection measures are in place.

E. Tree- and Plant-Protection Zones: Protect according to requirements in Section 311001 "Plant Protection."

F. Soil Stripping, Handling, and Stockpiling: Perform only when the soil is dry or slightly moist.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Stockpiled Top Soil / Planting Soil material: Requirements for satisfactory planting soil material are specified in section 329000 “Planting”

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed according to requirements in Section 31 10 01 "Plant Protection."

C. Protect existing site improvements to remain from damage during construction.
   1. Restore damaged improvements to their original condition, as acceptable to District.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

A. Protect trees and plants remaining on-site according to requirements in Section 31 10 01 "Plant Protection."

B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations according to requirements in Section 31 10 01 "Plant Protection."

3.4 EXISTING UTILITIES

A. District will arrange for shutting off utilities. Contractor is responsible for disconnecting, capping and sealing indicated utilities that serve existing structures before site clearing.
   1. Verify that utilities have been disconnected and capped before proceeding with site clearing.
B. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place. Arrange with utility companies to shut off indicated utilities.

C. Locate, identify, and disconnect utilities indicated to be abandoned in place.

D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by District or others, unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify District not less than two days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without District's written permission.

E. Excavate for and remove underground utilities indicated to be removed, refer to section 312300 Excavation section.

3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
   1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
   2. Grind down stumps and remove roots larger than 1 inch in diameter, obstructions, and debris to a depth of 18 inches below exposed subgrade.
   3. Use only hand methods or air spade for grubbing within protection zones.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
   1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm), and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

A. Contractor to strip and stockpile existing on-site top soil per plans and submit quantity and soil report. If stockpiled top soil is determined to be an acceptable planting soil, contractor to provide credit to owner for reduced quantity of imported planting soil. All planting areas to receive 12” of imported planting soil (refer to Section 329000).

B. Remove sod and grass before stripping topsoil.

C. Strip topsoil to depth encountered and no more than 12” in a manner to prevent intermingling with underlying subsoil or other waste materials.
   1. Remove subsoil and non-soil materials from topsoil, including clay lumps, gravel, and other objects larger than 2 inches (50 mm) in diameter; trash, debris, weeds, roots, and other waste materials.

D. Stockpile topsoil away from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
   1. Limit height of topsoil stockpiles to 72 inches.
   2. Mechanically mix each topsoil stockpile uniformly to produce a homogeneous soil texture prior to soil testing each stockpile for agricultural suitability.
   3. Do not stockpile topsoil within protection zones.
   4. Dispose of surplus topsoil after final soil placement. Surplus topsoil is that which exceeds quantity indicated to be reused.
3.7 STOCKPILING ROCK

A. Remove from **construction area** naturally formed rocks that measure more than 1 foot across in least dimension. Do not include excavated or crushed rock.
   1. Separate or wash off non-rock materials from rocks, including soil, clay lumps, gravel, and other objects larger than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.

B. Stockpile rock **away from edge of excavations** without intermixing with other materials. Cover to prevent windblown debris from accumulating among rocks.
   1. Limit height of rock stockpiles to **36 inches**.
   2. Do not stockpile rock within protection zones.
   3. Stockpile surplus boulders larger than 24” diameter to allow later use by the District.
      Contractor to remove stockpiled rock at no cost to owner if rocks are rejected for reuse.

3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil and rock material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off District’s property.

B. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION
SECTION 312300 - EXCAVATION AND FILL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section describes the requirements for earthwork operation, as shown on the Drawings and specified:

1. Excavation and/or embankment from existing ground to subgrade, including soil sterilant, for parking areas, walks, paths, and any other site improvements called for on the Plans.
   a. Aggregate base.
   b. Dispose off-site waste, excess or unsatisfactory material.

1.2 RELATED DOCUMENTS

A. Geotechnical Report: "Geotechnical Engineering Investigation Report, C-4016 New Allied Science Building, Contra Costa College, 2600 Mission Bell Drive, San Pablo, California." Kleinfelder Project No.: 20181569.001A, Dated: October 17, 2017, including:

1. Addendum Letters No. 1 and No. 2 dated March 2 and March 4, 2018, respectively.

B. Caltrans Standard Specifications:
   1. Section 17, Watering.
   2. Section 19, Earthwork.
   3. Section 26, Aggregate Bases.

1.3 RELATED SECTIONS

A. Section 31 11 00 – Clearing and Grubbing

1.4 REGULATORY REQUIREMENTS

A. State of California, Department of Transportation (Caltrans), Standard Specifications

B. ASTM
   1. D 1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.
   2. D1557-70 for testing in compaction.
   3. D 1586, Method for Penetration Tests and Split-Barrier Sampling of Soils.
   4. D 2487, Classification of Soils for Engineering Purposes.


D. CAL/OSHA, Title 8.

### 1.5 DEFINITIONS

A. Borrow: Approved soil material imported from off-site for use as Structural Fill or Backfill.

B. Structural Backfill: Soil materials approved by the District’s Representative and used to fill excavations resulting from removal of existing below grade facilities, including trees.

C. Structural Fill: Soil materials approved by the District’s Representative and used to raise existing grades.

D. Rock: Rock material in beds, ledges, unstratified masses, and conglomerate deposits and boulders of rock material ¾-cubic yards or more in volume that when tested by an independent geotechnical testing agency, according to ASTM D 1586, exceeds a standard penetration resistance of 100 blows/2-inches.

E. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man made stationary features constructed above or below grade.

F. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below base or topsoil materials.

G. Unsuitable Material: Any soil material that is not suitable for a specific use on the Project. The District’s Representative will determine if a soil material is unsuitable.

H. Utilities: onsite underground pipes, conduits, ducts and cables.

### 1.6 SUBMITTALS

A. Submittal procedure shall be as outlined in Division 1 – General Requirements.

B. Submit material certificates signed by the material producer and the Contractor, certifying that each material item complies with, or exceeds the specified requirements.

### 1.7 QUALITY ASSURANCE

A. Conform all work and materials to the recommendations or requirements of the District’s
Representative.

B. Percentage of compaction specified shall be the minimum acceptable. The percentage represents the ratio of the dry density of the compacted material to the maximum dry density of the material as determined by the procedure set forth in ASTM D 1557.

C. Excavate and backfill existing areas only to extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations. Backfill as necessary to achieve rough grade elevations as indicated per plan.

D. Perform excavation, filling, compaction and related earthwork under the observation of the District’s Representative. Materials placed without approval of the District’s Representative will be presumed to be defective and, at the discretion of the District’s Representative, shall be removed and replaced at no cost to the District. Notify the District’s Representative at least 24-hours prior to commencement of earthwork and at least 48 hours prior to testing.

E. The District’s Representative will perform observations and tests required to enable him to form an opinion of the acceptability of the Project earthwork. Correct earthwork that, in the opinion of the District’s Representative, does not meet the requirements of these Technical Specifications.

F. Upon completion of the construction work, certify that all compacted fills and foundations are in place at the correct locations, and have been constructed in accordance with sound construction practice. In addition, certify that the materials used are of the types, quality and quantity required by these Technical Specifications. The Contractor shall be responsible for the stability of all fills and backfills constructed by his forces and shall replace portions that in the opinion of the District’s Representative have been displaced or are otherwise unsatisfactory due to the Contractor’s operations.

G. Do not mix or place cement treated base when the temperature is below is below 36 degrees F or when the ground is frozen.

H. Identify and protect existing utilities.

I. Finish soil grade tolerance at completion of grading:
   1. Paved areas: +0.05 feet.
   2. Other areas: ±0.10 feet.

1.8 PROJECT CONDITIONS

A. Promptly notify the District and the District’s Representative of surface or subsurface conditions differing from those disclosed in conformance with Division 1 General Requirements.

B. Protect open excavations, trenches, and the like with fences, covers and railings to maintain safe pedestrian and vehicular traffic passage.

C. Prevent erosion of freshly graded areas during construction and until such time as permanent drainage and erosion control measures have been installed.

D. Temporarily stockpile fill material in an orderly and safe manner and in a location approved by the District.
E. Provide dust and noise control in conformance with Division 1 General Requirements.

F. Environmental Requirements: When unfavorable weather conditions necessitate interrupting earthwork operation, areas shall be prepared by compaction of surface and grading to avoid collection of water. Provide adequate temporary drainage to prevent erosion. After interruption, compaction specified in last layer shall be re-established before resuming work.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from on-site excavations.

B. Obtain approval of on-site soil materials and borrow materials to be used for structural fill or structural backfill from the District’s Representative.

C. On-Site Structural Fill and Structural Backfill: Soil or soil-rock mixture from on site excavations, free from organic matter or other deleterious substances. On-site structural fill and backfill shall not contain rocks or rock fragments over 3 inches in greatest dimension.

D. Imported Structural Fill and Structural Backfill: Conform to the requirements of on-site structural fill. Material shall also be non-expansive with a plasticity index of 12 or less, has a liquid limit less than 30, and has an expansion index less than 20. Gradation should meet the criteria in the following table:

<table>
<thead>
<tr>
<th>Fill Requirement</th>
<th>Test Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradation</td>
<td>ASTM¹</td>
</tr>
<tr>
<td>Sieve Size</td>
<td>Percent Passing</td>
</tr>
<tr>
<td>3 inch</td>
<td>100</td>
</tr>
<tr>
<td>¾ inch</td>
<td>70-100</td>
</tr>
<tr>
<td>No. 200</td>
<td>20-50</td>
</tr>
<tr>
<td>Plasticity</td>
<td></td>
</tr>
<tr>
<td>Liquid Limit</td>
<td>Plasticity Index</td>
</tr>
<tr>
<td>&lt;50</td>
<td>&lt;12</td>
</tr>
<tr>
<td>Organic Content</td>
<td>No visible organics</td>
</tr>
<tr>
<td>Expansion Potential</td>
<td>20 or less</td>
</tr>
<tr>
<td>Soluble Sulfates</td>
<td>Less than 1,000 ppm</td>
</tr>
<tr>
<td>Soluble Chloride</td>
<td>Less than 300 ppm</td>
</tr>
<tr>
<td>Resistivity</td>
<td>Greater than 2,000 ohm-cm</td>
</tr>
</tbody>
</table>

¹American Society for Testing and Materials Standards (latest edition)
²State of California, Department of Transportation, Standard Test Methods (latest edition)

2.2 SOIL STERILANT

A. Commercial chemical for weed control, registered by EPA. Provide granular, liquid or wet-able powder form.
2.3 AGGREGATE BASE

   1. Class 2, 1-1/2-inch Maximum: Section 26-1.02B.
   2. Class 2, 3/4-inch Maximum: Section 26-1.02B.
   3. Class 3: Section 26-1.02C.

PART 3 - EXECUTION

3.1 GENERAL

A. Conform to Section 19, Earthwork, Caltrans Standard Specifications as modified by the Contract Documents.

B. Placement and compaction of material by flooding, ponding, or jetting will not be permitted.

C. The use of explosives will not be permitted.

3.2 WET WEATHER CONDITIONS

A. Do not prepare subgrade, place or compact soil materials if above optimum moisture content.

B. If the District’s Representative allows work to continue during wet weather conditions, conform to supplemental recommendations provided by the District’s Representative and the project Geotechnical Report.

3.3 EXCAVATION

A. Excavate earth and rock to lines and grades shown on drawings as prepared by a licensed professional engineer and to the neat dimensions indicated on the Plans, required herein or as required to satisfactorily compact backfill.

B. Remove and dispose of large rocks, pieces of concrete and other obstructions encountered during excavation.

C. Where forming is required, excavate only as much material as necessary to permit placing and removing forms.

D. Provide supports, shoring and sheet piles required to support the sides of excavations or for protection of adjacent existing improvements. Refer to Section 31 50 00 – Temporary Excavation Support and Protection.

3.4 GRADING

A. Uniformly grade the Project to meet existing conditions.

B. Finish ditches, gutters and swales to the sections, lines and grades indicated and to permit...
proper surface drainage.

C. Round tops and bottoms of slopes as indicated or to blend with existing contours.

D. Temporary cuts shall be no steeper than one (1) horizontal to one (1) vertical.

3.5 SUBGRADE PREPARATION

A. Prepare subgrades under structures, building slabs, of other surface facilities and areas to receive structural fill. A four (4) inch layer of three quarter (3/4) inch crushed rock or slab capillary break material shall be underlain with at least sixteen (16) inches of “non-expansive” fill material for a total of 20 inches of non-expansive material. The material shall be placed beneath exterior flatwork and extend at least five (5) feet beyond the slab edges. Slab subgrade soils will also need to be properly moisture-conditioned prior to the placement of the “non-expansive” material.

1. Scarify the top twelve (12) inches of underlying subgrade soils, moisture-conditioned to at least two (2) percent above optimum moisture content, and compacted to ninety (90) percent relative compaction per ASTM D1557.

B. Prepare subgrades for walks, paved areas, curbs and gutters by scarifying surface at least twelve (12) inches in one lift below final subgrade elevations and a minimum of two (2) feet beyond edge of pavement unless specified otherwise by the District’s Representative. Uniformly moisture condition to obtain optimum moisture contents. Break clods and condition surface by harrowing or dry rolling. Remove boulders, hard ribs and solid rock. Prepare earth uniform for full depth and width of subgrade. In a similar fashion, exterior concrete flatwork should be underlain by six (6) inches of “non-expansive” material along with proper moisture conditioning of the subgrade soil.

1. Scarify the top twelve (12) inches of underlying subgrade soils, moisture-conditioned to at least two (2) percent above optimum moisture content, and compacted to ninety (90) percent relative compaction per ASTM D1557. The upper 6-inches of pavement subgrade should be compacted to ninety-five 95 percent relative compaction.

C. Protect utilities from damage during compaction of subgrades and until placement of final pavements or other surface facilities.

D. Obtain the District’s Representative’s approval of subgrades prior to placing pavement.

3.6 REUSE OF ONSITE MATERIALS

A. On-site clay soils encountered across the site are considered suitable for reuse as general engineered fill provided they are not placed within the upper two (2) feet of areas supporting improvements or permanent slopes or wall backfill unless chemically treated with sufficient high-calcium quicklime. Engineered fill consisting of native clayey soils placed deeper than two (2) feet from finished soil grades in permanent slopes or wall backfill should be compacted to between eighty-eight (88) and ninety-two (92) percent relative compaction at a moisture content at least three (3) percent above optimum. Native clayey soils supporting structural loads should be compacted to between ninety (90) and ninety-three (93) percent relative compaction at a moisture content at least two (2) percent above optimum.

B. If necessary, the native clayey soils may be placed in the upper two (2) feet of areas...
supporting improvements if they have been chemically treated. One approved chemical treatment is the use of lime at an application rate of four (4) to five (5) pounds of lime per cubic foot of soil treated or as determined by laboratory testing of soil samples obtained from on-site borrow areas prior to construction by the contractor. Final lime application rates should be determined such that a stabilized fill material with an expansion index of less than twenty (20) (based on ASTM test method D4829) is achieved. The lime-stabilized soil should be compacted to at least ninety (90) percent relative compaction at a moisture content of at least two (2) percent above optimum, based on ASTM D1557. The upper 6 inches of subgrades supporting exterior slabs or pavements should be compacted to at least ninety-three (93) percent of the maximum dry density. Lime treatment should be performed by a specialty contractor experienced in this work and should be performed in accordance with Caltrans Standard Specifications Section 24-2. Lime-treated areas can have significantly elevated pH levels (pH over ten (10)) and may not be appropriate for use in landscaped areas. If used beneath improvements, appropriate corrosion protection should be provided.

3.7 PLACEMENT OF STRUCTURAL FILL

A. Obtain the District’s Representative’s approval of surface to receive structural fill prior to placement of structural fill material.

B. Place structural fill on prepared subgrade.

C. Fills greater than five (5) feet in depth shall be compacted to ninety-five (95) percent of the maximum dry density as determined by ASTM Test Method D 1557.

D. Spread structural fill material placed in horizontal lifts less than eight (8) inches in loose thickness, and compact to between ninety (90) and ninety-three (93) percent of the maximum dry density.

E. The uppermost six (6) inches of structural fill underneath exterior slabs and pavement where vehicular traffic is expected shall be compacted to a minimum of ninety-five (95) percent of the maximum dry density.

F. Place structural fill material to suitable elevations above grade to provide for anticipated settlement and shrinkage.

G. Overbuild fill slopes, as required by the District’s Representative, to obtain required compaction. Remove excess material to lines and grades indicated. Native soils used to construct permanent slopes or backfill shoring or retaining walls deeper than 2 feet should be moisture conditioned to at least three (3) percent above optimum and compacted to between eighty-eight (88) and ninety-two (92) percent of the maximum dry density.

H. Do not drop fill on structures. Do not backfill around, against or upon concrete or masonry structures until structure has attained sufficient strength to withstand loads imposed and the horizontal structural system had been installed.

I. Permanent slopes should be constructed utilizing benching and subdrain collection pipes as indicated on the plans.
3.8 AGGREGATE BASE

A. Watering, Spreading and Compacting: Section 26-1.03, of Caltrans Standard Specifications.

3.9 COMPACTION AND TESTING

A. Do not compact by ponding, flooding or jetting.

B. Aerate material if it is too wet. Add water to material if it is too dry. Thoroughly mix lifts before compaction to ensure uniform moisture distribution.

C. Perform compaction using rollers, pneumatic or vibratory compactors or other equipment and mechanical methods approved by the District’s Representative.

D. Compaction requirements:
   1. Compact structural fills less than five (5) feet thick to ninety (90) percent compaction.
   2. Compact structural fill five (5) feet thick or greater to ninety-five (95) percent compaction.
   3. Compact the upper six (6) inches of subgrade soils beneath pavements, curbs and gutters to ninety-five (95) percent compaction. Extend compaction two (2) feet beyond pavement edges unless specified otherwise by the District’s Representative.
   4. Compact the upper six (6) inches of subgrade soils under walks, structures and areas to receive structural fill to ninety (90) percent compaction.

3.10 SOIL STERILIZATION

A. Apply soil sterilant to areas indicated, such as beneath asphalt concrete pavement, brick pavement, concreter pavement and at grade concrete slabs, including sidewalks, curbs and gutters. Also where indicated apply soil sterilant below expansion and control joints and at areas where pipes, ducts or other features penetrate slabs.

B. Apply soil sterilant uniformly and at the rates recommended by the manufacturer.

C. Apply soil sterilant to prepared subgrade, or after installation of aggregate base as recommended by the manufacturer.

3.11 DISPOSAL

A. Lawfully dispose of all unsuitable and excess or surplus material off-site at no cost to the District.

END OF SECTION
SECTION 312300 - STRUCTURAL EXCAVATION AND FILL

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Geotechnical Report: "Geotechnical Engineering Investigation Report, C-4016 New Science Building, Contra Costa College, 2600 Mission Bell Drive, San Pablo, California". Kleinfelder Project No.: 20181569.001A, dated October 17, 2017 and Geologic and Hazard Assessment Report dated October 20, 2017 and Addendum Letters No. 1, No 2, No. 3 and No. 4 dated March 2, March 14, 2018, August 16 and December 12, 2018 respectfully are available in accordance with “Information Available to Bidders.”

1.2 SUMMARY

A. This Section Includes:
   1. Excavation for foundations and pits.
   2. Backfilling structural excavations as required.

B. Related Sections:
   1. Division 03 “Concrete” for formwork for footings.
   2. Division 31 “Earthwork” for mass excavation and/or fill for building pad.

1.3 REFERENCES


B. American Concrete Institute (ACI):
   1. ACI 301 - Specifications for Structural Concrete for Buildings, 2010.
   2. ACI 229R – Controlled Low Strength Materials, 2013.

C. California Department of Transportation’s (Caltrans):

1.4 SITE CONDITIONS

A. Notify Owner’s Representative when site conditions differ from findings of Geotechnical Investigation Report.
PART 2 – PRODUCTS

2.1 MATERIALS

A. Concrete: Concrete materials and proportions shall be in accordance with ACI 301 to produce concrete with minimum compressive strength of 2500 psi at 28 days.

B. Structural Fill: CSS Section 26, Class 2 Aggregate Base rock, 3/4” size.

C. Controlled Low Strength Material: Machine mixed, self-compacting, low-strength fill consisting of fine aggregate, cementitious materials, entrained air and water. Mix and mixing shall conform to recommendations of ACI 229 to achieve the following properties:

1. Slump: 8 to 10 inches.
2. Compressive Strength:
   a. For backfill: Minimum 150 psi to maximum 300 psi at 30 days.
   b. For fill beneath footings: Minimum 300 psi at 30 days.
3. Fresh Density: 115 to 145 pounds per cubic.
4. Subsidence: Minimal; a maximum of 1/16” per foot of thickness.

D. Pea Gravel: ASTM C 33, Size No 7.

1. Backfill material: Crushed rock of uniform gradation, 100% passing 3/4 inch sieve.

PART 3 – EXECUTION

3.1 PREPARATION

A. Take measures to prevent surface water from entering excavations.

B. Notify Geotechnical Engineer at least 48 hours prior to commencing and upon completion of excavations.

3.2 EXCAVATION

A. Accurately cut foundation excavations to dimensions and elevations shown on Drawings to tolerances of ACI 301.

B. Where sides are unstable or excavations are not accurately cut, over-excavate to permit placement and removal of formwork.

C. Shore and brace excavations as required to prevent caving and danger to persons and structures. Comply with applicable safety regulations.

D. Prepare bottoms of footing excavations to produce conditions acceptable to Owner’s Representative, based on professional opinion of Geotechnical Engineer.

1. The bottoms of excavations shall be firm, undisturbed earth, clean and free from loose material, debris and foreign matter.
2. Remove or recompact disturbed material.
3. Remove soft or unstable material to a depth satisfactory to Geotechnical Engineer.
4. Fill over-depth excavations with concrete, flowable fill, or structural fill compacted to minimum 95% relative compaction.

E. Maintain footing conditions approved by Geotechnical Engineer until concrete work is complete.
   1. In periods of wet weather, over-excavate footings and place 2-inches minimum concrete mud-slab as soon as practical after completing excavation.

F. Keep excavations free of water at all times until foundation concrete is cast.

G. Stockpile or remove excavated material from site in accordance with Division 31 Section “Earthwork”.

3.3 BACKFILLING

A. Place and compact fill in accordance with Division 31 “Earthwork”.
   1. Use pea gravel or controlled low strength material for backfill against sides of footings and pits, where adequate compaction of structural fill cannot be achieved.

B. Backfill footings after formwork is removed. Do not backfill pits until concrete has cured a minimum of 7 days.

3.4 FIELD QUALITY CONTROL

A. The Geotechnical Engineer will observe footing excavations prior to placement of reinforcement; and again, immediately prior to casting of concrete.

B. The Geotechnical Engineer will observe the placement of fill and backfill material.

END OF SECTION
SECTION 312333 - UTILITY TRENCHING AND BACKFILLING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Excavation, bedding, and backfill of underground storm drain, sanitary sewer and water piping and associated structures.

B. The CONTRACTOR shall provide all materials, equipment, and labor necessary to perform and complete all utility earthwork as shown on the Drawings and as specified herein.

C. The work of this Section includes all utility earthwork required for construction of the project. Such earthwork shall include, but may not necessarily be limited to, the loosening, removing, loading, transporting, depositing, and compacting in its final location of all materials wet and dry, as required for the purposes of completing the work, which shall include, but not necessarily be limited to, the furnishing, placing, and removing of sheeting, shoring and bracing necessary to safely support the sides of all excavations; all pumping, ditching, draining and other required measures for the removal or exclusion of water from the excavation; the supporting of structures above and below the ground; all backfilling around structures and all backfilling of trenches and pits; the disposal of excess excavated materials; borrow of materials to make up deficiencies for fills; and all other incidental earthwork.

D. Hazardous materials shall be handled in accordance with all regulatory agency requirements. Asbestos cement pipe (ACP) exists within the project area and replacement of existing ACP is anticipated but shall be abandoned in place unless otherwise noted in the plans. The contractor shall make every attempt to protect all asbestos containing items during the execution of this contract. However, there will be instances where ACP or asbestos containing material will need to be removed, handled, cut, disturbed, or disposed of and the contractor shall comply with all local, state and federal regulations regarding construction activities near asbestos containing materials.

1.2 SECTION EXCLUDES

A. Drainage fill material and placement around subdrains.

B. Power, telecommunications, and low voltage scope of work.

1.3 RELATED DOCUMENTS

A. Geotechnical Report: “Geotechnical Engineering Investigation Report, C-4016 New Allied Science Building, Contra Costa College, 2600 Mission Bell Drive, San Pablo, California.” Kleinfelder Project No.: 20181569.001A, Dated: October 17, 2017, including:

B. Addendum Letters No. 1 and No. 2 dated March 2 and March 4, respectfully.

C. ASTM:
   1. C 33, Specification for Concrete Aggregates.
   7. D 2487, Classification of Soils for Engineering Purposes.


E. CAL/OSHA, Title 8.

1.4 RELATED SECTIONS
   A. Section 31 11 00, Clearing and Grubbing.

1.5 DEFINITIONS
   A. AC: Asphalt Concrete.
   C. Bedding: Material from bottom of trench to bottom of pipe.
   D. CDF: Controlled Density Fill.
   E. DIP: Ductile Iron Pipe.
   F. Initial Backfill: Material from bottom of pipe to 12-inches above top of pipe.
   G. PCC: Portland Cement Concrete.
   H. RCP: Reinforced Concrete Pipe.
   I. Springline of Pipe: Imaginary line on surface of pipe at a vertical distance of ½ the outside diameter measured from the top or bottom of the pipe.
J. Subsequent Backfill: Material from 12-inches above top of pipe to subgrade of surface material or subgrade of surface facility or to finish grade.

K. Trench Excavation: Removal of material encountered above subgrade elevations and within horizontal trench dimensions.
   1. Authorized Trench Over-Excavation: Excavation below trench subgrade elevations or beyond indicated horizontal trench dimensions as shown on plans or authorized by the Geotechnical Consultant.
   2. Unauthorized Trench Over-Excavation: Excavation below trench subgrade elevations or beyond indicated horizontal trench dimensions without authorization by the Geotechnical Consultant. Unauthorized excavation shall be without additional compensation.

L. Utility Structures:
   1. Storm Drain Manholes, vaults, etc.
   2. Sanitary sewer manholes, vaults, etc.
   3. Water vaults, etc.

1.6 SUBMITTALS

A. Follow Submittal procedure outlined in Division 0 – General Conditions and Division 1 – General Requirements

B. Product Data:
   1. Grading and quality characteristics showing compliance with requirements for the Work.
   2. Certify that material meets requirements of the Project.
   3. Aggregate for Structural Soil Mix.

C. Samples:
   1. If required by the Geotechnical Consultant, provide 40-pound samples of all imported trench bedding and backfill material sealed in airtight containers, tagged with source locations and suppliers of each proposed material. Do not import materials to Project without written approval of the Geotechnical Consultant.
   2. Provide materials from same source throughout work. Change of source requires approval of the Geotechnical Consultant and the District’s Representative’s.

D. Material Test Reports: Provide, from a qualified testing agency, the following test results showing compliance with the project requirements:
   1. Classification according to ASTM D 2487 of each imported trench bedding and backfill material.
   2. Laboratory compaction curve in conformance with ASTM D 1557 for each imported trench bedding and backfill material
   3. Structural Soil Mix Testing: Provide a two-gallon representative sample to laboratories for an analysis of the structural soil mix indicating the following:
      a. Particle size analysis, including the following gradients of mineral content (USDA Designated Size in mm):
         1) 3” (76mm)
         2) 2 ½” – 3” (63-76mm)
         3) 2” – 2 ½” (50-83mm)
4) 1 ½” – 2” (37-50mm)
5) 1” (25-37mm)
6) ¾” (19-25mm)
7) Fine gravel – 1/8” – ¾” (2-19mm)
8) Sand – 0.05 -2mm
9) Silt – 0.002-0.05mm
10) Clay – minus 0.002mm

b. Provide manufacturer’s analysis of the following:
   1) Loose and rodded unit weight.
   2) Bulk specific gravity and absorbance.
   3) Gravel dimension and surface texture description.
   4) Aggregate soundness and L.A. abrasion.

c. Sample Collection Procedure:
   1) Collect a minimum of eight samples to make up the composite sample.
   2) Take samples from random locations in the stockpile varying from the top to
      the bottom and around the stockpile.
   3) Take at least half the samples from the lower third of the stockpile into a clean
      bucket.
   4) Thoroughly mix material after samples are taken.
   5) Remove 2 gallon of material from bucket and fill a zip-lock plastic bag.
   6) Double bag the composite sample and label the bag with a permanent marker
      indicating the material name and date sample was taken.

1.7 QUALITY ASSURANCE

A. Provide an independent testing agency qualified according to ASTM E 329 to conduct soil
   materials and rock definition testing, as documented according to ASTM D 3740 and ASTM E
   548.

B. Conform all work and materials to the recommendations or requirements of the Geotechnical
   Report and meet the approval of the Geotechnical Consultant.

C. Percentage of compaction specified shall be the minimum acceptable. The percentage
   represents the ratio of the dry density of the compacted material to the maximum dry density of
   the material as determined by the procedure set forth in ASTM D 1557.

D. The Geotechnical Consultant will perform observations and tests required to enable him to form
   an opinion of the acceptability of the trench backfill. Correct the trench backfill that, in the
   opinion of the Geotechnical Consultant, does not meet the requirements of these Technical
   Specifications and the Geotechnical Report.

1.8 PROJECT CONDITIONS

A. Promptly notify the District’s Representative of surface or subsurface conditions differing from
   those disclosed in the Geotechnical Report. First notify the District’s Representative verbally to
   permit verification and extent of condition and then in writing. No claim for conditions differing
from those anticipated in the Contract Documents and disclosed in the Geotechnical Report will be allowed unless Contractor has notified the District’s Representative in writing of differing conditions prior to contractor starting work on affected items.

B. Protect open, trenches, and utility structure excavations with fences, covers and railings to maintain safe pedestrian and vehicular traffic passage.

C. Stockpile on-site and imported backfill material temporarily in an orderly and safe manner.

D. Provide dust and noise control in conformance with Division 1.

E. Areas to receive structural soil mix shall be inspected by the Owner’s Representative before starting work.

PART 2 - PRODUCTS

2.1 PIPE BEDDING AND INITIAL BACKFILL

A. ASTM D 2321, Class IA, IB or II.
   1. Clean and free of clay, silt or organic matter.

B. Class 2 Aggregate Base: Conform to Section 26 of Caltrans Standard Specifications, ¾-inch maximum.


2.2 SUBSEQUENT BACKFILL

A. Conform to on-site or imported structural backfill in Section 31 23 00, Excavation and Fill.

2.3 CONTROLLED DENSITY FILL (CDF) (IN TRENCHES)

A. Provide non-structural CDF, from bottom of trench to finish subgrade of subbase or base material, that can be excavated by hand and produce unconfined compressive 28-day strengths from 50-psi to a maximum of 150-psi. Provide aggregate no larger than 3/8-inch top size. The 3/8-inch aggregate shall not comprise more than 30% of the total aggregate content.

B. Cement: Conform to the standards as set forth in ASTM C-150, Type II Cement.

C. Fly Ash: Conform to the standards as set forth in ASTM C-618, for Class F pozzolan. Do not inhibit the entrainment of air with the fly ash.

D. Air Entraining Agent: Conform to the standards as set forth in ASTM C-260.
E. Aggregates need not meet the standards as set forth in ASTM C-33. Any aggregate, producing performances characteristics described herein will be accepted for consideration. The amount of material passing a #200 sieve shall not exceed 12% and no plastic fines shall be present.

F. Provide CDF that is a mixture of cement, Class F pozzolan, aggregate, air entraining agent and water. CDF shall be batched by a ready mixed concrete plant and delivered to the job site by means of transit mixing trucks.

G. The Contractor shall determine the actual mix proportions of the controlled density fill to meet job site conditions, minimum and maximum strengths, and unit weight. Entrained air content shall be a minimum of 4.0%. The actual entrained air content shall be established for each job with the materials and aggregates to be used to meet the placing and unit weight requirements. Entrained air content may be as high as 20% for fluidity requirements.

H. Mix design shall meet the Geotechnical Consultant’s approval.

2.4 CONCRETE STRUCTURE BEDDING AND BACKFILL

A. Precast Structures: Same materials to the same heights as specified for pipe bedding and backfill, or other material approved by the Geotechnical Consultant.

B. Poured-in-Place Structures:
   1. Bedding: Bedding shall meet the approval of the Geotechnical Consultant. In general, bedding is not required, pour bases against undisturbed native earth in cut areas and against engineered fill compacted to 90% relative compaction in embankment areas.
   2. Side Backfill: On-site or imported structural fill meeting the requirements given in Section 31 23 00.
   3. Structural Soil Mix: TMT Enterprises, 1996 Oakland Road, San Jose, CA 915131; (408)432-9010

2.5 AGGREGATE FOR STRUCTURAL SOIL MIX:

A. Aggregate shall be triangular.

B. Aggregate shall not be limestone or sandstone.

C. Aggregate shall pass a 3-inch screen and be retained on a 2-inch screen.

D. Aggregate dimensions shall not exceed 1.5:1.0 for any two dimensions chosen.

2.6 SOIL FOR STRUCTURAL SOIL MIX:

A. Soil shall be a “clay loam” or “clay” based on “USDA classification system” as determined by mechanical analysis and shall be of uniform composition, without admixture of subsoil.

B. Soil shall be free of stones greater than one-half inch, plants, roots, debris and other extraneous
matter larger than one inch in diameter or an excess of smaller pieces of same type materials as determined by Owner’s Representative.

C. Soil shall not contain toxic substances harmful to plant growth.

D. Soil shall be obtained from naturally well drained areas which have never been stripped of topsoil before and have a history of satisfactory vegetative growth.

E. Soil shall contain not less than 3% or more than 7% organic matter as determined by organic carbon and total nitrogen on oven-dried samples.

F. Soil shall be the product of a commercial processing facility specializing in production of Structural Soil Mixes for a minimum of 5 years.

G. Mechanical analysis:
   1. Textural Class: Based on material passing a 2 mm screen.
   2. Gravel: Less than 5%.
   3. Sand: 20 – 50%.
   4. Silt: 20 – 30%.
   5. Clay: 25- 60%.

H. Chemical analysis:
   1. pH: Between 6.5 to 7.9.
   3. Nutrient level:
      a. Fertility: The range of the essential elemental concentration in soil shall be as follows.

         Ammonium Bicarbonate/DTPA Extraction parts per million (mg/kgolram) dry weight basis.

         | Element    | Range   |
         |------------|---------|
         | Phosphorous| 10-40   |
         | Potassium  | 100-200 |
         | Iron       | 5-35    |
         | Manganese  | 0.6-6   |
         | Zinc       | 1-8     |
         | Copper     | 0.3-5   |
         | Boron      | 0.2-1   |
         | Magnesium  | 50-150  |
         | Sodium     | 0-100   |
         | Sulfur     | 25-500  |
         | Molybdenum | 0.1-2   |

      b. Toxic elements and compounds and excessive nutrients below UC guidelines and soil testing laboratory guidelines. The maximum permissible elemental concentration in the soil.

         Ammonium Bicarbonate/DTPA Extraction parts per million (mg/kgolram) dry weight basis.

         | Element  | Range   |
         |----------|---------|
         | Arsenic  | 1       |
2.7 STRUCTURAL SOIL MIX

A. Content:
   1. 4 parts structural soil aggregate.
   2. 1 part soil, treated with polymer.

B. Mixing:
   1. Mix polymer (PAM) with soil 48 hours ahead of blending with aggregate to allow for proper bonding.
   2. Cure polymer treated soil by allowing the soil to partially dry.
   3. Based upon accepted mix design, blend materials off-site in a clean area using an experienced blending operator.
   4. Uniformly blend materials so that they are evenly distributed throughout mixtures.
   5. Maintain adequate soil moisture content during mixing process.
   6. Soils and mix components shall easily shred and break down without clumping.
   7. Soil clods shall easily break down into a medium crumbly texture material.
   8. Do not blend materials that are saturated or contain excessive water.
   9. Measure and monitor amount of soils moisture at mixing site periodically during mixing process.
  10. Protect materials and mixtures from contamination prior to, during, and after mixing operations.
  11. Store mixes in stockpiles prior to shipment to site in clean areas protected from contamination from other materials.
  12. Reblend the mix if the components have separated.

2.8 FILTER FABRIC

A. Filter Fabric:
   2. Mirifi 140N (Mirifi Inc., Charlotte, NC) (Tel. 800-438-1855) or equal.

Cadmium 1
Chromium 10
Cobalt 2
Lead 30
Mercury 1
Nickel 5
Selenium 3
Silver 0.5
Vanadium 3

   c. Soluble salt: Less than 3.0 Millimho per cm in saturation extract.
   d. Boron: Less than 1 part per million in saturation extract.
   e. Sodium Absorption Ratio: Less than 4.
PART 3 - EXECUTION

3.1 TRENCHING AND EXCAVATION

A. Existing PCC or AC Areas: Cut PCC or AC to full depth at a minimum distance of 12-inches beyond the edge of the trench.

B. Excavate by hand or machine. For gravity systems begin excavation at the outlet end and proceed upstream. Excavate sides of the trench parallel and equal distant from the centerline of the pipe. Hand trim excavation. Remove loose matter.

C. Excavation Depth for Bedding: Minimum of 4-inches below bottom of pipe or as otherwise allowed or required by the Geotechnical Consultant, except that bedding is not required for nominal pipe diameters of 2-inches or less.

D. Excavation Width at Springline of Pipe:
   1. Up to a nominal pipe diameter of 24-inches: Minimum of twice the outside pipe diameter, or as otherwise allowed or required by the Geotechnical Consultant.
   2. Nominal pipe diameter of 30-inches through 36-inches: Minimum of the outside pipe diameter plus 2-feet, or as otherwise allowed or required by the Geotechnical Consultant.
   3. Nominal pipe diameter of 42-inches through 60-inches: Minimum of the outside pipe diameter plus 3-feet, or as otherwise allowed or required by the Geotechnical Consultant.

E. Over-Excavations: Backfill trenches that have been excavated below bedding design subgrade, with approved bedding material.

F. Comply with the District’s Representative’s limitations on the amount of trench that is opened or partially opened at any one time. Do not leave trenches open overnight without the approval of the District’s Representative.

G. Where forming is required, excavate only as much material as necessary to permit placing and removal of forms.

H. Bottoms of trenches will be subject to testing by Geotechnical Consultant. Correct deficiencies as directed by the Geotechnical Consultant.

I. Grade bottom of trench to provide uniform thickness of bedding material and to provide uniform bearing and support for pipe along entire length. Remove stones to avoid point bearing.

3.2 CONTROL OF WATER AND DEWATERING

A. Be solely responsible for dewatering trenches and excavations and subsequent control of ground and surface water. Provide and maintain such pumps or other equipment as may be necessary to control ground water and seepage to the satisfaction of the Geotechnical Consultant and the District’s Representative until backfilling is completed.
B. Dewater during backfilling operation so that groundwater is maintained a least one foot below level of compaction effort.

C. Obtain the Geotechnical Consultant’s approval for proposed control of water and dewatering methods.

D. Reroute surface water runoff away from open trenches and excavations. Do not allow water to accumulate in trenches and excavations.

E. Maintain dewatering system in place until dewatering is no longer required.

3.3 BRACING AND SHORING

A. Conform to California and Federal OSHA requirements.

B. Place and maintain such bracing and shoring as may be required to support the sides of the excavations for the proper protection of workmen; to facilitate the work; to prevent damage to the pipes and appurtenances being constructed; and to prevent damage to adjacent structures or facilities. Remove all bracing and shoring upon completion of the work.

C. Be solely responsible for all bracing and shoring and, if requested by the District’s Representative, submit details and calculations to the District’s Representative. The District’s Representative may forward the submittal to the Geotechnical Consultant, the Consulting Engineer and/or the California Division of Industrial Safety for their review. The Contractor’s submittal shall include the basic design, assumed soils conditions and estimation of forces to be resisted, together with plans and specifications of the materials and methods to be used, and shall be prepared by a civil engineer or structural engineer registered in California. No excavations in trench section or around structures shall precede a response to the submittal by the District’s Representative.

D. Be solely responsible for installing and extracting the sheathing in a manner which will not disturb the line, grade, or backfill compaction or operation of the utility being installed or adjacent utilities and facilities.

3.4 PIPE BEDDING

A. Obtain approval of bedding material from the Geotechnical Consultant.

B. Accurately shape bedding material to the line and grade called for on the Plans. Carefully place and compact bedding material to the elevation of the bottom of the pipe in layers not exceeding 8-inches in loose thickness. Compact bedding material at optimum water content to 90% relative compaction for sand and 95% relative compaction for fine gravel unless specified otherwise on the Plans or by the Geotechnical Consultant. Compact by pneumatic tampers or other mechanical means approved by the Geotechnical Consultant. Jetting or ponding of bedding material will not be permitted.
C. Upon completion of bedding operations, and prior to the installation of pipe, notify the Geotechnical Consultant, who will inspect the bedding layer. Do not commence pipe laying until the Geotechnical Consultant has approved the bedding.

3.5 BACKFILLING

A. Obtain approval of backfill material from Geotechnical Consultant.

B. Bring initial backfill up simultaneously on both sides of the pipe, so as to prevent any displacement of the pipe from its true alignment. Carefully place and compact initial backfill material to an elevation of 12-inches above the top of the pipe in layers not exceeding 8-inches in loose thickness. Compact initial backfill material at optimum water content to 90% relative compaction for sand and 95% relative compaction for fine gravel unless specified otherwise on the Plans or by the Geotechnical Consultant. Compact by pneumatic tampers or other mechanical means approved by the Geotechnical Consultant. Jetting or ponding of initial backfill material will not be permitted.

C. Bring subsequent backfill to subgrade or finish grade as indicated. Carefully place and compact subsequent backfill material to the proper elevation in layers not exceeding 8-inches in loose thickness. Compact subsequent backfill material at optimum water content to 90% relative compaction, except in areas subject to vehicular traffic shall be compacted to at least 95% relative compaction, unless specified otherwise on the Plans or by the Geotechnical Consultant. Compact by pneumatic tampers or other mechanical means approved by the Geotechnical Consultant. Jetting or ponding of subsequent backfill material will not be permitted.

D. Do not use compaction equipment or methods that produce horizontal or vertical earth pressures which may cause excessive pipe displacement or damage the pipe.

E. Utility backfill shall be inspected and tested by the Geotechnical Consultant during placement. Cooperate with the Geotechnical Consultant and provide working space for such tests in operations. Backfill not compacted in accordance with these specifications shall be re-compacted or removed as necessary and replaced to meet the specified requirements, to the satisfaction of the Geotechnical Consultant and the District’s Representative prior to proceeding with the Project.

3.6 STRUCTURAL SOIL MIX INSTALLATION

A. Place mix carefully to avoid damage or displacement of other materials such as paving, drain rock, geotextile fabric and irrigation piping.

B. Do not mix subgrade soils on construction materials with mix.

C. Remove soil mix contaminated with subgrade soil, construction materials or debris.

D. Maintain mix in a moist, but not saturated, condition to prevent segregation of mix during placement.
E. Install mix in 6 inch lifts in locations indicated on the Drawings.

F. Compact lifts to 95 percent compaction in compliance with Geotechnical Investigation Report. Schedule the Geotechnical Engineer to perform nuclear density field tests after each lift of mix to confirm compaction.

G. Install final lift of mix to elevations indicated on the Drawings.

3.7 CLEANUP

A. Upon completion of utility earthwork all lines, manholes catch basins, inlets, water meter boxes and other structures shall be thoroughly cleaned of dirt, rubbish, debris and obstructions of any kind to the satisfaction of the District’s Representative.

END OF SECTION
SECTION 312500 - EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section describes the requirements for providing and installing temporary erosion and sedimentation control structures as specified.

1.2 SUBMITTALS

A. Follow Submittal procedure outlined in Division 0 – General Conditions and Division 1 – General Requirements.

1.3 REGULATORY REQUIREMENTS:


B. State Water Resources Control Board (SWRCB) standards.


PART 2 - PRODUCTS

2.1 Furnish and install the products as specified in the Storm Water Pollution and Prevention Plan and as required by the SWRCB required to eliminate potential erosion and sedimentation during construction works. Products which shall be installed, but are not limited to, are the following:

A. Siltation fences

B. Outlet structure, basins, ditches

C. Filter fabric, and/or mesh

D. Hydroseeding

E. Wattle and/or Gravel bags

PART 3 - EXECUTION

3.1 GENERAL

A. A Storm Water Pollution Prevention Plan (SWPPP) in accordance with the SWRCB application is to be prepared by the Engineer or the Contractor. The Contractor shall review the BMP’s selected
for the Project in the approved SWPPP, then prepare erosion and sediment control plans that are site specific that show the application of these approved BMPs. These site and increment specific erosion and sediment control plans shall be included in each increment package.

B. Erosion and sedimentation control measures are to be installed in areas only to extent required by new construction and as indicated or as directed by governing regulations.

C. The Contractor shall provide inspection and repair of established SWPPP applications and prepare maintenance reports of erosion control measures in accordance with approved SWPPP.

END OF SECTION
SECTION 315000 - TEMPORARY EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes temporary excavation support and protection systems.

B. Temporary excavation support performance: Design, furnish, install, monitor, and maintain temporary excavation support and protection system capable of supporting temporary excavation sidewalls and of resisting soil, which will require a back drainage system as to eliminate hydrostatic pressures, and superimposed and construction loads.

1. Delegated Design: Design temporary excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

2. Prevent surface water from entering temporary excavations by grading, dikes, or other means.

3. Install temporary excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to temporary excavation.


1.2 RELATED SECTIONS

A. Section 31 23 19: Dewatering

1.3 REGULATORY REQUIREMENTS

A. Geotechnical Report: “Geotechnical Engineering Investigation Report, C-4016 New Allied Science Building, Contra Costa College, 2600 Mission Bell Drive, San Pablo, California.” Kleinfelder Project No.: 20181569.001A, Dated: October 17, 2017, including:

B. Addendum Letters No. 1 and No. 2 dated March 2 and March 4, 2018, respectively.

C. Addendum Letter No 3 dated August 8, 2018.


1.4 SUBMITTALS

A. Shop Drawings: For temporary excavation support and protection system.

B. Delegated-Design Submittal: For temporary excavation support and protection system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Other Informational Submittals:

1. Record Drawings: Identifying and locating capped utilities and other subsurface structural, electrical, or mechanical conditions.
a. Note locations and capping depth of wells and well points.

1.5 QUALITY ASSURANCE

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review methods and procedures related to temporary excavation support and protection system including, but not limited to, the following:
      a. Geotechnical report and addendums.
      b. Existing utilities and subsurface conditions.
      c. Proposed temporary excavations.
      d. Proposed equipment.
      e. Monitoring of temporary excavation support and protection system.
      f. Working area location and stability.
      g. Coordination with waterproofing.
      h. Abandonment or removal of temporary excavation support and protection system.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by the College or others unless permitted under Division 1.

B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer.
   1. Make additional test borings and conduct other exploratory operations necessary for temporary excavation support and protection.
   2. The geotechnical report and addendums are referenced elsewhere in the Project Manual.

C. Survey Work: Engage a land surveyor or professional engineer with a California license to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
   1. During installation of temporary excavation support and protection systems, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Architect if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Furnish and install the following as specified herein and required to eliminate potential erosion and sedimentation during construction works.
   1. Structural steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.
   2. Steel sheet piling with continuous interlocks: ASTM A 328/A 328M, ASTM A 572/A 572M,
or ASTM A 690/A 690M; with continuous interlocks
3. Wood Lagging: Preservative treated lumber, mixed hardwood, nominal rough thickness of size and strength required for application
4. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.
5. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
6. Tiebacks: Steel bars, ASTM A 722/A 722M.
7. Tiebacks: Steel strand, ASTM A 416/A 416M.

2.2 LEED REQUIREMENTS
A. Provide documentation necessary to satisfy the LEED requirements for Construction Activity Pollution Prevention Plan which will be part of the SWPPP.

PART 3 - EXECUTION

3.1 PREPARATION
A. Contractor to engage surveyor or engineer to survey adjacent existing structures and site improvements before and regularly during installation of temporary excavation support and protection system.
B. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during temporary excavation support and protection system operations.
   1. Shore, support, and protect utilities encountered.
C. Install temporary excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
   1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the College and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
D. Contractor shall protect in place the existing roadways, sidewalks and structures adjacent to the project area.
E. Locate temporary excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces are not impeded.
F. Monitor temporary excavation support and protection systems daily during temporary excavation progress and for as long as temporary excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that temporary excavation support and protection systems remain stable.
G. Promptly repair damages to adjacent facilities caused by installing temporary excavation support and protection systems.

3.2 SOLDIER PILES AND LAGGING
A. Install steel soldier piles before starting temporary excavation. Extend soldier piles below
temporary excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than tolerances as specified by a qualified professional engineer.

B. Install wood lagging within flanges of soldier piles as temporary excavation proceeds. Trim temporary excavation as required to install lagging. Fill voids behind lagging with soil, and compact.

C. Install wales horizontally at locations indicated on Drawings as prepared by a qualified professional engineer and secure to soldier piles.

3.3 SHEET PILING

A. Before starting temporary excavation, install one-piece sheet piling lengths and tightly interlock to form a continuous barrier. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to tolerances as specified by a qualified professional engineer Accurately align exposed faces of sheet piling to vary not more than tolerances as specified by a qualified professional engineer. Cut tops of sheet piling to uniform elevation at top of temporary excavation.

3.4 BRACING

A. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.
1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Architect.
2. Install internal bracing, if required, to prevent spreading or distortion of braced frames.
3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and a backdrainage system is in place as to eliminate hydrostatic pressures.

3.5 REMOVAL AND REPAIRS

A. Remove temporary excavation support and protection systems when construction has progressed sufficiently to support temporary excavation and bear soil and a backdrainage system is in place as to eliminate hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.
1. Remove temporary excavation support and protection systems to a minimum depth of 48 inches (1200 mm) below overlaying construction and abandon remainder.
2. Fill voids immediately with approved backfill compacted to density specified in Section 31 23 00 Excavation and Fill.*
3. Repair or replace, as approved by the College, adjacent work damaged or displaced by removing temporary excavation support and protection systems.

B. Leave temporary excavation support and protection systems permanently in place as directed by the Architect.
3.6 DISPOSAL
   A. Lawfully dispose of all unsuitable and excess or surplus material off-site at no cost to the College.

3.7 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL
   A. General: Comply with General Contractor’s Waste Management Plan and Division 1.
   B. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the General Contractor's Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

END OF SECTION
SECTION 316800 - FOUNDATION TIEDOWN ANCHORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.


1.2 SUMMARY

A. This Section includes:

1. Permanent tiedown anchors used to provide resistance to seismic uplift forces, including drilling, grouting, stressing, load testing and lock-off.

1.3 SYSTEM REQUIREMENTS

A. Contractor design responsibility: Contractor shall determine the bond length, borehole diameter and grouting method to achieve the performance requirements, subject to the minimum requirements of the Contract Documents.

B. Performance requirements:


2. Each tiedown anchor shall be capable of sustaining an Ultimate Load (UL) as designated on Drawings, when performance tested in accordance with Part 3 of this Section.

C. Minimum requirements:

1. Contractor shall not be permitted to adjust the location and number of tiedown anchors or change the anchor bar size or type from that designated in the Contract Documents.

2. Minimum borehole diameter shall be as designated on Drawings.

3. Free-stressing length designated on Drawings is a minimum requirement. Free-stressing length shall not exceed specified minimum by more than five feet unless approved by Owner's Representative, considering affect on anchor elongation.

4. Minimum length of bonded zone shall be as designated on Drawings.

5. Provide the minimum total anchor length designated on Drawings to achieve the required load capacity of anchor groups, where indicated.

D. Performance Verification: All tiedown anchors shall be tested in accordance with Part 3 of this Section.
1. Contractor shall complete the initial performance testing program prior to installation of additional anchors.

1.4 REFERENCES

A. Standards listed below apply where designation is cited in this Section. Where the applicable year of adoption or revision is not listed below, the latest edition applies.

B. ASTM: Standards of the American Society for Testing and Materials (ASTM) apply where cited in this Section.

C. PTI: Post-Tensioning Institute’s “Recommendations for Prestressed Rock and Soil Anchors”, 2014 (PTI DC35.1-14)

1.5 DEFINITIONS

A. Alignment Load (AL): A nominal load applied to an anchor during testing to keep the testing equipment positioned correctly.

B. Design Load (DL): As designated on Drawings. The Design Load is the maximum anchor load determined using allowable stress load combinations.

C. Free-stressing length: The length of the anchor bar that is not bonded to the surrounding ground or grout during stressing, measured from the bearing plate.

D. Lock-off load: The prestressing force after transferring the load from the jack to the foundation, as specified on the Drawings.

E. Ultimate Load (UL): The maximum load to which performance test anchors are subjected, equal to the maximum load determined based on load combinations for strength design using overstrength factors and not exceeding .8 x the specified minimum tensile strength of the tiedown anchor. Anchors designated for performance testing shall be subjected to UL as designated on the Drawings.

F. Proof Load (PL): The maximum load to which production anchors are subjected, equal to 133% of DL.

G. Tiedown: A system used to transfer tensile loads to soil or rock that includes the anchor bar, anchorage, corrosion protection, sheathings, centralizers, and grout.

1.6 SUBMITTALS

A. Submittal procedures and administrative provisions are established by Division 01 Section "Submittals".

B. Qualifications: Project lists for the Anchor Installer.

C. Design calculations: Provide test load, nominal borehole diameter, bond length and free-stressing length for each tiedown. Indicate basis for determination of bond length. Identify minimum and maximum anchor deformation under Maximum Test Load.
1. Calculations shall bear the seal and signature of a Civil Engineer registered in the State of California.

D. Fabrication drawings: Indicate bar size and material. Provide detailed drawing of factory installed corrosion protection and sheath systems, including end terminations. Provide detailed drawing of anchor zone, including all anchorage components. Indicate location and type of centering devices.

E. Installation and monitoring procedures: Provide detailed written procedure to be followed for installing anchors, including description of equipment and methods to be used. Describe procedures for monitoring grout quality, volume of grout, and grouting pressure during installation. Include form proposed for preparation of standard daily log.

F. Load testing procedures: Describe procedures to be employed for load testing.
   1. Submit certified calibration charts for each test jack, pressure gauge, master gauge, and load cell to be used.

G. Mill test reports: Submit test reports certifying compliance with specified standards to Testing Agency for record purposes.
   1. Anchor bars.
   2. Cement.

H. Mix design for grout.

1.7 QUALITY ASSURANCE

A. Installer qualifications: Not less than 5 successfully completed projects within the preceding 5 years with similar site conditions, shaft sizes, and anchor test loads.

B. Preinstallation conference: Conduct conference at project site to comply with requirements in Division 01 Section "Project Management and Coordination."
   1. Schedule: Three weeks minimum prior to installation of tiedown anchors.
   2. Attendees: For the Contractor, include representatives of the Anchor Installer and their Professional Engineer. For the Owner, include representatives of the Geotechnical Engineer and Testing Agency.
   3. Agenda: General Contractor shall review status of submittals and discuss outstanding items and proposed schedule for work. Anchor Installer shall present procedures for installation, testing, and monitoring. Roles and responsibilities for testing, inspection and monitoring by Contractor, Geotechnical Engineer, and Testing Agency will be reviewed and coordinated. Process for response to field conditions that require modification to approved drawings will be reviewed.

C. Each anchor shall be load tested by the Contractor, with observation by the Geotechnical Engineer and Owner’s Testing Agency in accordance with "Load Testing" provisions of this Section.
   1. Jacks shall be calibrated, and load versus gauge pressure/load cell reading curves provided for each pressure gauge, for 25 percent and 75 percent of the minimum jack extension for two cycles of loading, over the full range of expected load usage. At least six (6) load increments shall be applied, and all measured points shall be shown on the calibrations.
2. Provide means to measure load application within an accuracy of plus or minus five percent (5%).

1.8 PRODUCT HANDLING AND STORAGE

A. Handle anchor bars in such a manner to ensure that bars are not bent and that corrugated PVC sheathing is not damaged. Repair damage to sheathing in accordance with the manufacturer’s recommendations.

B. Maintain anchors free of soil. Do not drag on ground. Store off ground on suitable supports.

PART 2 - PRODUCTS

2.1 TIEDOWNS

A. General: Factory fabricate tiedown anchor assemblies as one continuous unit to achieve 100-year certified PTI Class I (Double Corrosion Protection) in the completed installation.

B. Acceptable products: Dywidag Threadbar® Anchors with Double Corrosion Protection, SAS Stressteel Inc. threadbars with DCP, or Williams Threadbar with Multiple Corrosion Protection III (No substitutions).

C. Anchor bar: Alloy steel threaded bars fabricated from steel conforming to ASTM A722, with a minimum tensile strength of 150,000 psi, and manufacturer’s standard threaded deformations.

D. Factory corrosion protection: Anchor bars shall be encapsulated in a corrugated plastic sheath over the full length of the anchor. The annular space between the bar and the sheath shall be completely filled with encapsulation grout. Encase corrugated sheathing in a smooth plastic sheath over the free-stressing length and tape ends.

1. Plastic sheaths: High density polyethylene (HDPE) according to ASTM D1248, Type III, or polyvinyl chloride (PVC) according to ASTM D1784, Class 13464-B.
   a. Corrugated sheath: Sheath shall have a minimum wall thickness of 1.5 mils. Inside diameter shall be 1/2-inch minimum larger than the anchor bar diameter, measured from the outside of anchor bar deformations. Outside diameter shall be 1/2-inch minimum larger than inside diameter.
   b. Smooth sheath: Tube or pipe with a minimum wall thickness of 0.10 inches. Inside diameter shall not be more than 0.25 inches larger than outside diameter of corrugated sheath. Outside diameter shall not exceed 4 inches.
   c. The materials for accessories such as end caps, grouting caps, grout tubes and sealing caps shall have properties equal to the plastic sheath.

2. Encapsulation grout: A combination of Type I or II Portland cement and potable water. Chemical admixtures that retard set or reduce bleeding may be used. Other admixtures shall be allowed only with approval of Owner’s Representative.

3. Tape: 20 mil thick by minimum 2 inch wide polyethylene tape. Same as 3M Scotchrap™ All-Weather Corrosion Protection Tape 51, or approved equal.

E. Accessories: Furnish manufacturer’s standard accessories as necessary for complete installation.
2.2 GROUT

A. A pumpable mixture of Types I or II Portland cement, water, and admixtures. Chemical additives which can control bleed or retard set may be used. Expansive additives will not be allowed. Additives, if used, shall be mixed in accordance with the manufacturer's recommendations.

1. The grout shall achieve a minimum compressive strength of 2,500 psi at 7 days and 3,500 psi at 28 days. Grout must achieve a compressive strength of 3000 psi at the time of stressing.

2. The grout shall bleed less than 2 percent when allowed to stand for 1 hour.

F. Fabrication:

1. Shop fabricate anchor bar assemblies. Field splice only as necessary and with approval of Owner's Representative.

2. Anchor bars shall be cut with an abrasive saw.

3. All of the bond length shall be free of dirt, lubricants, or other deleterious substances that may significantly affect bond or the service life of the anchor.

4. Encapsulation grouting shall be done on an inclined frame or bed by injecting the grout from the low end of the anchor.

5. Joints in the plastic sheath shall be made watertight.

5. Centralizers: PVC devices that will position the anchor bar assembly at the center of the shaft and will hold it securely in place during grout placement. The centering devices shall not interfere with grout placement. Place at 10-foot intervals along bond length.

6. Covers: Steel or plastic cover that forms a permanent watertight enclosure for the anchor head. Cover shall provide minimum 1 inch vertical clearance over top of anchor bar. Cover shall positively and securely fasten to bearing plate. Cover shall have provision for filling with corrosion inhibiting compound.

Th
3. Subject to compliance with requirements, fine aggregate (sand) and/or fly ash may be added to grout mix.

2.3 MISCELLANEOUS

A. Corrosion-inhibiting compound: Grease or wax with appropriate moisture-displacing, corrosion-inhibiting additives, and self-healing properties. The compound shall permanently stay viscous and be chemically stable and non-reactive with the prestressing steel, the sheathing material, and the anchor grout. Compound shall comply with Table 4.1 of PTI "Recommendations for Prestressed Rock and Soil Anchors"

2.4 SOURCE QUALITY CONTROL

A. Inspection and testing will be performed under provisions of Division 01 Section, “Quality”.

B. Testing Agency will:
   1. Review manufacturer's test reports for compliance with specified requirements.
   2. Verify material identification.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform field engineering and layout work including furnishing necessary centerlines, offsets, and grade stakes.

B. Notify the Geotechnical Engineer at least four working days in advance of the beginning of work or on resumption of work after stoppage. Any hole drilled or cast without continuous observation of the Geotechnical Engineer will be rejected.

3.2 INSTALLATION

A. Install tiedown anchors in accordance with approved layout drawings and installation and monitoring procedures.

B. Tolerances:
   1. Plan location: Plus or minus 3 inches.
   2. Vertical alignment: Shafts out of plumb, or differing from prescribed angle, not more than 1.5 percent of length.
   3. Where specified tolerances are exceeded, provide corrective construction to compensate for eccentricity as determined by Owner’s Representative. Corrective construction is subject to DSA review and approval as a CCD.

C. Minimum formwork: Case top 2 feet of anchor shaft with leave-in place metal, plastic or fiber tube. Formwork may remain in place. Backfill around form with clean sand upon completion of anchor.
3.3 LOAD TESTING

A. Test installed tiedowns in accordance with the procedures herein prior to installation of foundations.

B. Load testing shall be performed by Contractor, under the observation of Geotechnical Engineer.

C. Testing shall be performed in accordance with provisions of PTI “Recommendations for Prestressed Rock and Soil Anchors”, except as modified herein.

D. Testing apparatus: Apparatus for applying loads shall be in accordance with ASTM D3689.
   1. Maintain 8 feet clear distance between test anchor and cribbing.
   2. Equipment shall be calibrated in accordance with Section 8.2 of PTI “Recommendations for Prestressed Rock and Soil Anchors”.

E. Verification Load Testing (Pre-Production Testing) as required by the project Geotechnical Engineer. Test 3 sacrificial pre-production anchors.
   1. Test anchors using the Performance Test procedures and loading schedule (Table 8.1) of PTI “Recommendations for Prestressed Rock and Soil Anchors” except as modified herein. Add two additional loading steps to Table 8.1 as follows.
      a. Loading step 7. Apply load according to the following increments: AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, 1.20 DL, 1.33 DL, 1.60 DL.
      b. Loading step 8. Apply load according to the following increments: AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, 1.20 DL, 1.33 DL, 1.60 DL, UL.
   2. In the Pre-Production Testing, the anchor is incrementally loaded and unloaded. At each increment, the movement of the anchor bar is recorded. The loading at each increment.
During performance testing, the movement of the stressing end of the anchor shall be recorded at each increment of loading and at 1- and 10- minutes. If the total movement between the 1 and 10 minute readings exceeds 0.04 inches, hold the load for 50 additional minutes. The movement shall then be recorded at 15, 20, 25, 30, 45, and 60 minutes.

**F.** During Pre-Production Testing, the movement of the stressing end of the anchor shall be monitored to the nearest 0.001 inches using a free-standing dial gauge. Measurements shall be recorded at each increment of loading and at 1- and 10- minutes.

1. Plot a graph of total anchor movement at each load increment.
2. Acceptance criteria:
   a. The total elastic movement shall exceed 80% of the theoretical elastic movement of the anchor bar over the free-stressing length.
   b. The total elastic movement shall not exceed the theoretical elastic movement of the anchor bar over the free-stressing length plus one half of the bonded length.
   c. The total movement, measured during the final cycle of loading, shall not exceed the designated performance criteria.
   d. The creep rate does not exceed 0.080 inches/log cycle during the final log cycle of the test.

**G.** Test the first 2 production anchors and 2% of the remaining using Performance Test procedures.

1. The test anchor locations are shown on the structural foundation plans. Geotechnical Engineer shall review and approve locations as representative of site conditions.
2. Do not install other anchors until tests are completed and accepted by Geotechnical Engineer.

**H.** Performance test procedures:

1. Test anchors using the Performance Test procedures and loading schedule (Table 8.1) of PTI “Recommendations for Prestressed Rock and Soil Anchors” except as modified herein. Add additional loading step to Table 8.1 as follows.
   a. Loading step 7. Apply load according to the following increments: AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, 1.20 DL, 1.33 DL, 1.60 DL.

2. In the performance test, the anchor is incrementally loaded and unloaded. At each increment, the movement of the anchor bar is recorded. The loading at each increment is held just long enough to obtain movement readings, but not longer than 1 minute. The maximum load is held for a minimum of 10 minutes, with movement readings taken at 1, 2, 3, 4, 6 and 10 minutes.

3. If the total movement between the 1 and 10 minute readings exceeds 0.04 inches, hold the load for 50 additional minutes. The movement shall then be recorded at 15, 20, 25, 30, 45, and 60 minutes.

**I.** During performance testing, the movement of the stressing end of the anchor shall be monitored to the nearest 0.001 inches using a free-standing dial gauge. Measurements shall be recorded at each increment of loading and at 1- and 10- minutes.

1. Plot a graph of total anchor movement at each load increment.
2. Acceptance criteria:
   a. The total elastic movement shall exceed 80% of the theoretical elastic movement of the anchor bar over the free-stressing length.
   b. The total elastic movement shall not exceed the theoretical elastic movement of the anchor bar over the free-stressing length plus one half of the bonded length.
   c. The total movement, measured during the final cycle of loading, shall not exceed the designated performance criteria.
d. The creep rate does not exceed 0.080 inches/log cycle during the final log cycle of the test.

J. Proof tests: All remaining anchors shall be Proof Tested.
1. Test anchors using the Proof Test procedures of PTI "Recommendations for Prestressed Rock and Soil Anchors".
2. The proof test measures the movement of the anchor during one cycle of incremental loading. The loading at each increment is held just long enough to obtain movement readings, but not longer than 1 minute. The maximum load is held for a minimum of 10 minutes, with movement readings taken at 1, 2, 3, 4, 6 and 10 minutes.
3. Apply the Proof Load (PL) according to the following increments: AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, 1.20 DL, 1.33 DL.
4. Hold Maximum Test Load for 10 minutes. If the total movement between the 1- and 10-minute readings exceeds 0.04 inches, hold the load for 50 additional minutes. The movement shall then be recorded at 15, 20, 25, 30, 45, and 60 minutes.
5. Acceptance Criteria:
   a. The total movement shall exceed 80% of the theoretical elastic movement of the anchor bar over free-stressing length, when measured between 0.50 DL and MTL.
   b. The creep rate does not exceed 0.080 inches/log cycle during the final log cycle of the test.

K. When, in the professional opinion of the Geotechnical Engineer, the proof test results for an anchor show significant variation from the performance test results, the Contractor shall perform a performance test on that anchor at no additional cost to Owner.
1. Allow for additional Performance Testing of 5 percent of the total number of anchors in Contract Price.

L. Defective anchors:
1. If an anchor fails to meet the above acceptance criteria for testing, then that anchor will be rejected. All rejected anchors shall be replaced or supplemented by anchors installed at locations approved by the Owner’s Representative, as required to provide the total anchor capacity indicated on the Drawings.
2. No extension or time or additional compensation will be provided for replacing or installing additional anchors.

M. Records: The Contractor shall provide the Owner’s Representative two (2) copies of test record for each anchor within five (5) days of each test. Test records shall include the information listed below.
1. General: Project identification, anchor identification, bar size and type, bond length, free-stressing length.
2. Grouting data: Date grouted, pressure and grout volume.
3. Test results: Date tested, test type (performance or proof) and graphs of results. Note any adjustments made during test and unusual occurrences during test.

3.4 LOCK-OFF
A. Preparation: Observe placement, sealing and securing of trumpet immediately prior to placement of foundation concrete. Verify that compressible material is installed over top of shaft.
B. Upon completion of foundations, stress anchor bars to lock-off and anchor. Provide a method of anchorage which will limit the load loss to not more than five percent of the lock-off load in the transfer of loads from the jacks to the footing.

C. Fill trumpet completely with corrosion preventative compound.

D. Install and seal cover and fill completely with corrosion preventative compound.

3.5 FIELD QUALITY CONTROL

A. Inspection and testing will be performed under provisions of Division 01 Section “Quality”.

B. Geotechnical Engineer will:
   1. Continuously observe drilling for anchors paying attention to the depths of soil and rock materials encountered. Notify Contractor and Owner’s Representative when depth of materials encountered varies from expected conditions.
   2. Continuously observe tiedown anchor installation. Notify Contractor and Owner’s Representative when grout volume or pressure deviates from observations of test program.
   3. Monitor load testing and recording of results.
   4. Perform final determination of the acceptability of installed tiedown anchors; assign reduced capacity to tiedown anchors that fail to comply with specified requirements.
   5. Compile records of each tiedown anchor from Contractor’s log, Geotechnical Engineer’s observations, load testing, and as-built locations provided by the Contractor.
   6. Prepare final report.

C. Testing Agency will:
   1. Sample and test grout for compressive strength in accordance with ASTM C109.
   2. Observe final stressing, lock-off and installation of corrosion protection measures.

END OF SECTION
SECTION 320413 - COMMON SUBMITTAL REQUIREMENTS FOR EXTERIOR IMPROVEMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
B. Specific material goals, beyond inherently designed facility service systems, that may impact this area of work include: use of products with third-party verified Environmental Product Declaration, use of products with Health Product Declarations, use of products from manufacturers with publicly disclosed Corporate Sustainability Reports, use of products with recycled-content materials; use of locally-purchased, manufactured and extracted materials; use of FSC certified wood; use of low-emitting materials; construction waste recycling; and the implementation of a construction indoor air quality management plan.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:

   1. Action Codes Permitting Use:
      a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
      b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
      c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.
   1. Action Code for Information Only:
      a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
   1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
   1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering

1. Number submittals as described below to assist tracking.

2. Number each submittal in the format nnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 320523 - PORTLAND CEMENT CONCRETE PAVING

PART 1 - GENERAL

1.0 SECTION INCLUDES

A. Materials for Portland cement concrete.
B. Aggregate and aggregate grading for Portland cement concrete.
C. Water for Portland cement concrete.
D. Admixtures for Portland cement concrete.
E. Proportioning for Portland cement concrete.
F. Mixing and transporting Portland cement concrete.
G. Formwork for cast in place Portland cement concrete.
H. Embedded materials for Portland cement concrete.
I. Steel reinforcement for Portland cement concrete.
J. Placing and finishing Portland cement concrete.
K. Curing Portland cement concrete.
L. Protecting Portland cement concrete.

1.1 RELATED SECTIONS

A. Section 311100, Clearing and Grubbing

1.2 RELATED DOCUMENTS

A. ASTM:
   1. A 82, Cold Drawn Steel Wire for Concrete Reinforcement.
   2. A 185, Steel Welded Wire Fabric, Plain for Concrete Reinforcement.
   3. A 615, Deformed and Plain Billet Steel Bars, for Concrete Reinforcement.
   7. C 618, Fly Ash and Raw or Calcined Natural Pozzolan for use as Natural Admixture in Portland Cement.

B. Caltrans Standard Specifications:
1. Section 51: Concrete Structures.
2. Section 73: Concrete Curbs and Sidewalks.
3. Section 90: Concrete.

1.3 DEFINITIONS

A. ASTM: American Society for Testing Materials

1.4 SUBMITTALS

A. Follow Submittal procedure outlined in Division 0 – General Conditions and Division 1 – General Requirements.

B. Concrete Mix Design: Have all concrete mixes designed by a testing laboratory and approved by the Consulting Engineer. Conform all mixes to the applicable building code requirement, regardless of other minimum requirements listed herein or on the drawings. Submit mix designs for review before use. Show proportions and specific gravities of cement, fine and coarse aggregate, and water and gradation of combined aggregates.

1.5 QUALITY ASSURANCE

A. Concrete shall be subject to quality assurance in accordance with Section 90 of Caltrans Standard Specifications.

1. Slump tests: Have available, at job site, equipment required to perform slump tests. Make one slump test for each cylinder sample, from same concrete batch. Allowable maximum slump shall be 4 inches for walls and 3 inches for slab on grade.

B. Certifications:

1. Provide District’s Representative at the time of delivery with certificates of compliance signed by both Contractor and Supplier containing the following statements:
   a. Materials contained comply with the requirements of the Contract Documents in all respects.
   b. Proportions and mixing comply with the design mix approved by the Consulting Engineer. Design mix shall have been field tested in accordance with the herein requirements of the Caltrans Standard Specifications and produces the required compressive strength under like conditions.
   c. Statement of type and amount of any admixtures.

2. Provide District’s Representative, at time of delivery, with certified delivery ticket stating volume of concrete delivered and time of mixing, or time of load-out in case of transit mixers.

C. Conform to the applicable provisions of Section 51, 73 and 90 of the Caltrans Standard Specification and these Technical Specifications.

1. Conform construction of Portland cement concrete surface improvements (including curbs, gutters, medians, valley gutters, walks, pads) to the requirements of Section 73 of the Caltrans Standard Specifications unless otherwise required in these Technical Specifications or shown on the Plans.

2. Conform other construction of Portland cement concrete items to the requirements of Section 51 of the Caltrans Standard Specifications unless otherwise required in these Technical Specifications or shown on the Plans.
1.6 DESIGNATION

A. Unless noted otherwise herein or on the Plans, the minimum compressive strength for portland cement concrete at 28 days for this Project shall be 3,600 psi.

PART 2 - PRODUCTS

2.1 PORTLAND CEMENT

A. General: Type II (modified) cement conforming to section 90-2.01 of the Caltrans Standard Specifications.

2.2 AGGREGATE AND AGGREGATE GRADING

A. General: Conform to the requirements of Section 90-2.02, 2.02A and 2.02B of the Caltrans Standard Specifications.

B. Aggregate Size and Gradation: Conform to the requirements of Section 90-3 of the Caltrans Standard Specifications for 1-inch maximum combined aggregate.

2.3 WATER

A. General: Conform to the requirements of section 90-2.03 of the Caltrans Standard Specifications. For mixing and curing Portland cement concrete and for washing aggregates.

2.4 EXPANSION JOINT MATERIAL

A. Material for expansion joints in Portland cement concrete improvements shall be pre-molded expansion joint fillers conforming to the requirements of ASTM Designation D 1751. Expansion joint material shall be shaped to fit the cross section of the concrete prior to being placed. Suppliers certificates showing conformance with this specification shall be delivered with each shipment of materials delivered to the job site. Unless noted otherwise herein or on the Plans expansion joint thickness shall be as follows:
   1. Curbs, Curb Ramps, Sidewalks, Driveways and Gutter Depressions: \( \frac{1}{4} \)-inch.
   2. Gutter Lining, Ditch Lining and Channel Lining: \( \frac{3}{8} \)-inch.
   3. Structures: As indicated.

2.5 REINFORCEMENT AND DOWELS

A. Bar reinforcement for concrete improvements shall be deformed steel bars of the size or sizes called for on the plans conforming to the requirements of ASTM Designation A 615 for Grade 60 bars. Size and shape for bar reinforcement shall conform to the details shown or called for on the Plans.
B. Slip dowels, where noted or called for on the plans or detail drawings shall be smooth billet-steel bars as designated and conforming to the requirements of ASTM Designation A 615 for Grade 60 bars. Ends of bars inserted in new work shall be covered with a cardboard tube sealed with cork; no grease or oil shall be used.

C. Mesh for reinforcement for concrete improvements shall be cold drawn steel wire mesh of the size and spacing called for on the plans conforming to the requirements of ASTM Designation A 82 for the material and ASTM Designation A 185 for the mesh. Size and extent of mesh reinforcement shall conform to the details shown or called for on the plans.

D. Tie wire for reinforcement shall be eighteen (18) gauge or heavier, black, annealed conforming to the requirements of ASTM Designation A 82.

E. Suppliers certificates showing conformance with this specification shall be delivered with each shipment of materials delivered to the job site.

2.6 ACCESSORY MATERIALS

A. Conform water stops and other items required to be embedded in of portland cement concrete structures to the applicable requirements of Section 51 of the Caltrans Standard Specifications unless otherwise specifically noted or called for on the Plans or detail drawings.

B. Curing Compounds:
   1. Regular Portland Cement Concrete: "Non-Pigmented Curing Compound - Chlorinated Rubber Base-Clear" conforming to the requirements contained in Section 90-7.01B, of the Caltrans Standard Specifications.
   2. Color Conditioned Decorative Portland Cement Concrete: LITHOCHROME colorwax as manufactured by the L. M. Scofield Company or approved equal.

2.7 FORMS

A. Conform to the requirements of Section 51-1.05 of the Caltrans Standard Specifications.

2.8 PRECAST CONCRETE STRUCTURES

A. Conform to the following Sections of Caltrans Standard Specifications:
   1. 51-1.02, Minor Structures.
   2. 70-1.02C, Flared End Sections.
   3. 70-1.02H, Precast Concrete Structures.
PART 3 - EXECUTION

3.1 STRUCTURAL EXCAVATION

A. Structural excavation may be either by hand, or by machine and shall be neat to the line and dimension shown or called for on the plans. Excavation shall be sufficient width to provide adequate space for working therein, and comply with CAL-OSHA requirements.

B. Where an excavation has been constructed below the design grade, refill the excavation to the bottom of the excavation grade with approved material and compact in place to 95% of the maximum dry density.

C. Remove surplus excavation material remaining upon completion of the work from the job site, or condition it to optimum moisture content and compact it as fill or backfill on the site, if the material is approved by the Geotechnical Consultant.

3.2 SOIL STERILANT

A. Furnish and apply to areas indicated in accordance with Section 31 23 00, Excavation and Fill.

3.3 BRACING AND SHORING

A. Conform to California and Federal OSHA requirements.

B. Place and maintain such bracing and shoring as may be required to support the sides of the excavations for the proper protection of workmen; to facilitate the work; to prevent damage to the facility being constructed; and to prevent damage to adjacent structures or facilities. Remove all bracing and shoring upon completion of the work.

C. Be solely responsible for all bracing and shoring and, if requested by the District’s Representative, submit details and calculations to the District’s Representative. The District’s Representative may forward the submittal to the Geotechnical Consultant, the Consulting Engineer and/or the California Division of Industrial Safety for their review. The Contractor’s submittal shall include the basic design, assumed soils conditions and estimation of forces to be resisted, together with plans and specifications of the materials and methods to be used, and shall be prepared by a civil engineer or structural engineer registered in California. No excavations related to the proposed facility shall precede a response to the submittal by the District’s Representative.

D. Be solely responsible for installing and extracting the sheathing in a manner which will not disturb the position or operation of the facility being constructed or adjacent utilities and facilities.

3.4 PLACING CONCRETE FORMS

A. Form concrete improvements with a smooth and true upper edge. Side of the form with a smooth finish shall be placed next to concrete. Construct forms rigid enough to withstand the pressure of the fresh concrete to be placed without any distortion.
B. Thoroughly clean all forms prior to placement and coat forms with approved form oil in sufficient quantity to prevent adherence of concrete prior to placing concrete.

C. Carefully set forms to the alignment and grade established and conform to the required dimensions. Rigidly hold forms in place by stakes set at satisfactory intervals. Provide sufficient clamps, spreaders and braces to insure the rigidity of the forms.

D. Provide forms for back and face of curbs, lip of gutters and edge of walks, valley gutters or other surface slabs that are equal to the full depth of the concrete as shown, noted or called for on the Plans. On curves and curb returns provide composite forms made from benders or thin planks of sufficient ply to ensure rigidity of the form.

3.5 PLACING STEEL REINFORCEMENT

A. Bars shall be free of mortar, oil, dirt, excessive mill scale and scabby rust and other coatings of any character that would destroy or reduce the bond. All bending shall be done cold, to the shapes shown on the plans. The length of lapped splices shall be as follows:
   1. Reinforcing bars shall be lapped per the schedules shown on the Drawings.
   2. Splice locations shall be made as indicated on the plans.

B. Accurately place reinforcement as shown on the plans and hold firmly and securely in position by wiring at intersections and splices, and by providing precast mortar blocks or ferrous metal chairs, spacers, metal hangers, supporting wires, and other approved devices of sufficient strength to resist crushing under applied loads. Provide supports and ties of such strength and density to permit walking on reinforcing without undue displacement.

C. Place reinforcing to provide the following minimum concrete cover:
   1. Surfaces exposed to water: 4-inches.
   2. Surfaces poured against earth: 3-inches.
   3. Formed surfaces exposed to earth or weather: 2-inches.
   4. Slabs, walls, not exposed to weather or earth: 1-inch.

D. Minimum spacing, center of parallel bars shall be two and one half (2-1/2) times the diameter of the larger sized bar. Accurately tie reinforcing securely in place prior to pouring concrete. Placing of dowels or other reinforcing in the wet concrete is not permitted.

3.6 MIXING AND TRANSPORTING PORTLAND CEMENT CONCRETE

A. Transit mix concrete in accordance with the requirements of ASTM Designation C 94. Transit mix for not less than ten (10) minutes total, not less than three (3) minutes of which shall be on the site just prior to pouring. Mix continuous with no interruptions from the time the truck is filled until the time it is emptied. Place concrete within one hour of the time water is first added unless authorized otherwise by the District's Representative.

B. Do not hand mix concrete for use in concrete structures

3.7 PLACING PORTLAND CEMENT CONCRETE

A. Thoroughly wet subgrade when concrete is placed directly on soil. Remove all standing water prior to placing concrete.
B. Do not place concrete until the subgrade and the forms have been approved.

C. Convey concrete from mixer to final location as rapidly as possible by methods that prevent separation of the ingredients. Deposit concrete as nearly as possible in final position to avoid re-handling.

D. Place and solidify concrete in forms without segregation by means of mechanical vibration or by other means as approved by the District’s Representative. Continue vibration until the material is sufficiently consolidated and absent of all voids without causing segregation of material. The use of vibrators for extensive shifting of fresh concrete will not be permitted.

E. Concrete in certain locations may be pumped into place upon prior approval by the District’s Representative. When this procedure requires redesign of the mix, such redesign shall be submitted for approval in the same manner as herein specified for approval of design mixes.

3.8 PLACING ACCESSORY MATERIALS

A. Place water stops and other items required to be embedded in or Portland cement concrete structures at locations shown or required in accordance with Section 51 of the Caltrans Standard Specifications unless otherwise specifically noted or called for on the Plans.

B. Curing Compounds:
   1. Regular Portland Cement Concrete: Apply "Non-Pigmented Curing Compound - chlorinated Rubber Base-Clear" in accordance with Section 90-7.01B, 7.01D and 7.03 of the Caltrans Standard Specifications.
   2. Color Conditioned Decorative Portland Cement Concrete: Apply LITHOCHROME color-wax, or approved equal, in accordance with the manufacturer’s instructions.

3.9 EXPANSION JOINTS

A. Construct expansion joints incorporating pre-molded joint fillers at twenty (20) foot intervals in all concrete curbs, gutters, sidewalks, median/island paving, valley gutters, driveway approaches and at the ends of all returns. At each expansion joint install one-half inch by twelve inch (1/2" x 12") smooth slip dowels in the positions shown or noted on the detail drawings.

B. Orient slip dowels at right angles to the expansion joint and hold firmly in place during the construction process by means of appropriate chairs.

3.10 WEAKENED PLANE JOINTS

A. Construct weakened plane joints in concrete curbs, gutters, sidewalks, median/island paving and valley gutters between expansion joints at ten (10) foot intervals throughout, or as otherwise indicated. Depth of joint score depth to be one-fourth (25%) the thickness of the concrete.

   1. Grooved Joints: Form weakened plane joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8-inch. Repeat grooving of weakened plane joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.
   2. Sawed Joints: Form weakened plane joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch wide joints into concrete when cutting action will not tear, abrade or otherwise damage surface and before concrete develops random contraction cracks.
3.11 FORM REMOVAL
   A. Remove forms without damage to the concrete. Remove all shores and braces below the ground surface, before backfilling.
   B. Do not backfill against concrete until the concrete has developed sufficient strength to prevent damage.
   C. Leave forms for cast-in-place walls in place at least 72 hours after pouring.
   D. Leave edge forms in place at least 24 hours after pouring.

3.12 CONSTRUCTION
   A. Form, place and finish concrete curbs, walkways, island paving, valley gutters and driveway approaches in conformance with the applicable requirements of Section 73-1.04, 73-1.05, 72-1.05A and 73-1.06 of the Caltrans Standard Specifications as modified herein.
   B. Provide a medium broom finish to all horizontal surfaces unless otherwise shown.
   C. Construct new concrete curb, curb and gutter and valley gutters against existing asphalt concrete by removing a minimum of 12-inches of the asphalt concrete to allow placement of curb or gutter forms. Patch pavement with a 6-inch deep lift of asphalt concrete after gutter form is removed.
   D. Where monolithic curb, gutter and sidewalk is specified, separate concrete pours will not be allowed.

3.13 CONNECTING TO EXISTING CONCRETE IMPROVEMENTS
   A. New curb, gutter, or sidewalk is to connect to existing improvements to remain by saw cutting to existing sound concrete at the nearest score line, expansion joint or control joint. Drill and insert ½-inch diameter by 12-inch long dowels at 24-inches on center into existing improvements. Install pre-molded expansion joint filler at the matching joint.
   B. A cold joint to the existing curb is not acceptable.

3.14 DECORATIVE AND NON-DECORATIVE SURFACING CONSTRUCTION
   A. Decorative surfacing concrete walks or other installations shall be formed and placed as a concrete slab conforming to the details shown or noted on the Plans. Exposed aggregate concrete sidewalks shall be repaired in kind or better condition.
   B. Add lampblack or equivalent to the non-decorative surface concrete at the central mixing plant.

3.15 ACCESSIBLE PATH OF TRAVEL CONSTRUCTION FINISH
   A. Provide equivalent of medium salted finish at slopes less than 6% and slip-resistant finish at slopes 6% and greater along any accessible path of travel.
3.16 FIELD QUALITY CONTROL

A. Finish subgrade for concrete improvements shall be subject to approval prior to placement of forms.

B. No concrete shall be placed prior to approval of forms.

C. Concrete improvements constructed shall not contain areas that pond water and shall be smooth and ridge free.

D. Conform the finish grade at top of curb, flow line of gutter, and the finish cross section of concrete improvements to the design grades and cross sections.

E. Variation of concrete improvements from design grade and cross section as shown or called for on the plans shall not exceed the tolerances established in Sections 73-1.05 and/or 73-1.06 of the Caltrans Standard Specifications.

3.17 RESTORATION OF EXISTING IMPROVEMENTS

A. Replace in kind all pavement or other improvements removed or damaged due to the installation of concrete improvements.

B. Remove, landscaping or plantings damaged or disturbed due to the installation of concrete improvements. Replace in kind.

END OF SECTION
SECTION 320800 – COMMISSIONING OF IRRIGATION SYSTEMS

PART 1 - GENERAL

1.1. RELATED DOCUMENTS

A. The General Conditions, Supplementary Conditions and Division 01 are fully applicable to this Section, as if repeated herein.

1.2. RELATED WORK SPECIFIED ELSEWHERE

A. Division 01, Section 01910, General Commissioning Requirements
B. Division 22 and 32 Sections pertaining to Irrigation Systems and Controls.

1.3. REFERENCES

A. USGBC:
   1. LEED v4.0 Reference Guide for Building Design and Construction:
      a. Energy and Atmosphere Prerequisite: Fundamental Commissioning and Verification.

B. California Building Standards Commission:
   1. Title 24, Part 11, 2016, California Green Building Standards Code, Section 5.4.10.2 Commissioning.

C. ASHRAE:
   1. ASHRAE Guideline 0-2013: The Commissioning Process

1.4. DEFINITIONS

A. Basis of Design (BOD): The documentation of design criteria and assumptions for systems, components, and methods chosen to meet the Owner’s Project Requirements and applicable regulatory requirements, standards, and guidelines. The document includes narrative descriptions of the systems to be commissioned. The BOD is prepared by the Design Professionals.

B. Building Automation System (BAS): The automated building system providing control and user interaction with select building systems, such as the HVAC, domestic hot water and lighting systems. Also, often referred to as building management system (BMS), energy management system (EMS), or an energy management and control system (EMCS).

C. Commissioning (Cx): A quality-focused process to verify and document that building systems are installed and perform as intended per the OPR, BOD and design documents.

D. Commissioning Authority (CxA): An independent agent hired directly by the Owner and not otherwise associated with the Design Professionals or the General Contractor. The CxA is the
authority on commissioning results and other commissioning program elements completion, and assists the General Contractor with coordinating commissioning activities and witnesses the activities on behalf of the Owner.

E. Commissioning Issue: A condition that affects, prevents or inhibits commissioning, and must be resolved to complete the commissioning process.

F. Commissioning Issues & Recommendations Log (Cx Log): A log maintained by the CxA listing and describing all Cx issues and recommendations documented during the commissioning process, including providing the status, recommended action, contractor updates and resolution, and associated dates. All Cx issues require action, correction and closure.

G. Commissioning Report (Cx Report): The final report issued at the conclusion of the commissioning process. The report will include an executive summary abbreviating the outcome of the commissioning process and identifying all outstanding issues. The report also contains all commissioning documentation collected throughout all phases of the project.

H. Commissioning Plan (Cx Plan): A document that outlines the organization, coordination, and requirements of the commissioning process in more detail and contains project specific commissioning forms.

I. General Contractor (GC): The contractor directly contracted to the Owner with overall responsibility for the project and all commissioning activities described herein.

J. Commissioning Coordinator (CxC): Individual within the GC firm who plans, schedules, directs and coordinates all the Trade Subcontractor’s commissioning activities, and serves as the CxA’s single point of contact for all administrative, documentation and coordination functions.

K. Deferred Testing: Testing performed at a later time, due to partial occupancy, equipment, load, seasonal requirements, design or other site conditions that disallow the test from being performed prior to substantial completion.

L. Deficiency: A condition in the installation, function or performance of a component, equipment or system that is not in compliance with the contract documents and design. A deficiency will be considered a Cx issue and documented on the Cx Log.

M. Design Professional (DP): Architects, engineers and other consultants involved in the design of the project.

N. Functional Performance Test (FPT): A test of the dynamic function, operation and control of the equipment and systems to verify system performance to the fullest extent. Systems are tested under various operating modes and control sequences including failure modes. The FPTs are performed using manual (direct observation) or monitoring methods. The FPTs can include sequence of operation tests, performance tests, verification tests, integrated systems tests, and trend analysis. Functional performance tests are also often referred to as acceptance tests.

O. HVAC&R: Heating, ventilation, air conditioning and refrigeration.

P. Installation Verification (IV): Field verification and documentation of proper installation of system equipment, assemblies and components, per design documents and manufacturer requirements. The IV process is typically complete when systems are ready for startup or operation. IV is organized and documented under the System Readiness Checklist (SRC) forms.
Q. Monitoring: The recording of parameters (temperature, flow, current, status, pressure, etc.) of equipment operation, which shall be completed using data-loggers or the trending capabilities of BAS or control systems.

R. Owner’s Project Requirements (OPR): A document describing the operational and functional requirements of a project, the expectations of how the facility will be used and operated, and the equipment and system expectations and requirements, as defined by the Owner. This document provides an explanation of the ideas, concepts, goals, success criteria, and supporting information for the project.

S. Percent Sampling: Witnessing the startup, checkout or testing of a selected fraction of the total number of identical or near-identical pieces of equipment or systems.

T. Pre-Functional Checks and Tests (PFCT): These are various checks and tests performed on a piece of equipment or system before, during, or after the initial startup and operation, but prior to the FPT phase. They are performed to confirm the system equipment and individual components were installed correctly and are working properly and meeting applicable performance requirements and specifications. They are all organized and documented under the SRC forms and are to be completed prior to FPTs.

U. Startup: Initial starting or activating of equipment usually performed by the Trade Subcontractor or the Manufacturer’s authorized representative.

V. Systems Manual: A manual that provides the operating staff the information needed to understand and optimally operate the commissioned systems. It expands upon the scope of traditional operating and maintenance documents and is compiled of multiple documents such as the final BOD, single line diagrams, and as-built controls drawings and sequences of operation.

W. System Readiness Checklist (SRC): A construction checklist, typically one or two pages, listing the necessary commissioning tasks and required documentation to verify a system is ready for FPTs, or system operation if no FPTs are performed. The tasks covered in the SRC include IV, Startup and PFCT, and the Trade Subcontractor completed forms for these tasks are attached to the specific SRC. The SRC must be completed and signed by the GC prior to conducting the FPTs.

X. Trade Subcontractor: Typically, a subcontractor to the GC who provides and installs specific building components and systems and/or provides certain services.

Y. Trending: Monitoring using the BAS or a control system, to aid in functional testing and to verify system operation and performance under actual operating conditions.

Z. Warranty Phase: The phase of the project immediately after the initiation of the building equipment warranty which spans the entire length of the project warranty.

1.5. DESCRIPTION OF WORK

A. Systems and equipment to be commissioned:
   1. Landscape irrigation systems and controls.

B. The work includes the completion and documentation of formal commissioning procedures by the GC and Trade Subcontractors.
1. The GC and Trade Subcontractors shall provide the quality control for the installation, startup, checkout and testing of the systems. The commissioning process provides independent review throughout the process and qualitative functional performance testing in order to formally observe and document the quality control efforts are completed.

2. Refer to Section 01910, General Commissioning Requirements for summary description of the general commissioning process and requirements.

3. The Trade Subcontractors and the factory authorized service representatives shall be responsible for participation in the commissioning process as outlined in this specification and Section 01910, General Commissioning Requirements.

1.6. COMMISSIONING PROCESS

A. Submittal Reviews by the CxA

1. The CxA will review pertinent Trade Subcontractor submittals for the appropriate systems in the commissioning scope, concurrently with the Design Professionals and will provide review comments to the Design Professionals.

2. The GC shall provide a submittal log to the CxA for referencing the requested submittals to be reviewed by the CxA (for which the GC shall issue to the CxA concurrently with the submission to the Design Professionals). Alternatively, the GC shall include the CxA on the distribution of all Trade Subcontractor submittals issued to the Design Professionals, for systems applicable to this specification.

3. The GC shall issue the requested submittals to the CxA for review at the same time they issue the submittals to the Design Professionals.

4. The CxA will also use the information from the submittals to develop commissioning forms and test procedures.

B. Cx Plan and Form Development

1. The CxA prepares a Preliminary Cx Plan either during the project final design phase or early construction phase. The Cx Plan provides guidance in the execution of the commissioning process during construction and will contain the project specific commissioning forms.

2. Commissioning during construction begins with a kickoff meeting conducted by the CxA where the CxA reviews the commissioning process and responsibilities with the appropriate team members. The CxA presents the Preliminary Cx Plan and discusses the project specific requirements.

3. The CxA develops the SRC forms, which list the commissioning tasks and the associated IV, Startup, and PFCT documentation required for each system and equipment to be commissioned.

4. The CxA provides the SRC forms to the GC and Trade Subcontractors for review and comment.

5. The CxC shall submit to the CxA, for review and approval, the representative blank IV, Startup, and PFCT forms and plans for completing all IV, Startup, and PFCT tasks, prior to conducting any of these tasks.

a. IV forms are to provide field verification and documentation of proper installation of system equipment, assemblies and components, typically completed prior to formal Startup. Where appropriate and approved by the CxA, these forms may be combined with the Startup or PFCT forms.

   1) The IV forms are a combination of Trade Subcontractor provided forms (which may include any applicable design drawings, floor plans, details, or single line diagrams that will be field verified) and the applicable equipment IV (pre-startup) checklists contained in the Manufacturer’s installation manuals.
2) The Trade Subcontractors are to verify equipment installation per the Manufacturer’s guidelines and requirements, and thus are encouraged to use and complete any applicable equipment IV checklists contained in the Manufacturer’s installation manuals, in addition to any IV forms used by the Trade Subcontractors to verify system installation per design.

b. Startup forms consist of Manufacturer and/or Trade Subcontractor provided forms and plans used to document the completion of formal startup procedures and associated checks and verifications during the startup and initial operation. Where applicable, these forms shall include checks of the equipment internal / factory provided controls including sensors and control devices.

c. PFCT forms and plans are Trade Subcontractor provided forms and plans used to document the completion and results for the various checks and tests performed before, during, or after startup.

d. The CxA reviews the blank IV, Startup and PFCT forms and plans, and will issue any comments, which may include additions or changes to be made to the forms and plans, and/or supplemental forms may be issued by the CxA, where appropriate, to improve the forms and commissioning process.

6. The CxA will develop FPT procedures and forms, and provide the draft forms to the GC and Trade Subcontractors for review and comment.

7. The CxA will update and finalize the Cx Plan with equipment specific blank SRC, IV, PFCT and FPT forms.

C. System Readiness (Pre-Functional) Activities

1. Meetings will be conducted throughout construction with commissioning team members, as required, to plan, coordinate, and schedule commissioning activities, review documentation, and resolve Cx issues.

2. The Trade Subcontractors shall perform the IV, Startup and PFCT tasks for all systems and equipment (no sampling allowed), unless the contract or design documents allow for sampling of the pre-functional tests.

   a. In general, the GC and Trade Subcontractors should complete IV prior to Startup, but where appropriate and approved by the CxA, they can combine IV and Startup into one activity (and Startup is not performed if there are deficiencies identified from the IV).

3. The Trade Subcontractors and the CxC shall document completion of the IV, Startup and PFCT tasks on the IV, Startup, PFCT and SRC forms, and shall complete the SRC forms and attach the completed IV, Startup, and PFCT forms to the SRCs forms.

   a. The intent of the SRC forms is for the GC and Trade Subcontractors to certify that the irrigation systems, controls and instrumentation, equipment and assemblies have been installed, started, calibrated and are operating per the contract and design documents.

4. The CxA will review the completed IV, Startup, PFCT and SRC forms. The CxA will also perform various field observations and reviews, and witness a sample of the Startup and PFCT activities (some PFCT witnessing may be performed as back-checks after PFCT tasks are completed).

   a. The Trade Subcontractor shall resolve any IV and PFCT results deemed unacceptable by the CxA. And the Trade Subcontractor shall execute a new sample of the PFCT to be witnessed by the CxA. The CxA shall deem the PFCT acceptable after resolution of all issues and any witnessed sampling results in no issues.
5. The CxC shall submit all completed SRC forms to the CxA for review prior to conducting the FPTs. The CxA shall deem the SRCs acceptable after all SRC forms and supporting IV, Startup and PFCT forms are complete and any issues have been addressed.

D. Functional Performance Testing

1. FPTs are to test the dynamic function, performance and control of the equipment and systems under various modes of operation. These tests verify the correct implementation of the sequences of operation and the system performance meets the design criteria. The FPTs are performed using manual (direct observation) or monitoring methods. FPTs include the following types of tests, where applicable:

   a. Sequence of Operation Tests.
      1) Sequence of operation tests are witnessed by the CxA for each unique sequence of operation but may not necessarily be repeated across identical systems, equipment or spaces, if the contractor has verified the same programmed sequence of operation code (as tested) has been programmed across multiple identical systems, equipment or spaces, based sample verification tests witnessed by the CxA (see below).

   b. Verification Tests.
      1) Verification tests are often less detailed tests than the sequence of operation tests and are typically witnessed by the CxA at a higher sample rate. Examples of verification tests include:
         a) verifying the programmed sequence of operation code is the same as the as-tested code per the sequence of operation tests,
         b) verifying the alarm points are configured per the sequence of operation tests (without having to repeat the actual sequence tests),
         c) testing portions of the systems controls, such as irrigation zone control valve functions, or testing critical sequences, with a higher sample rate beyond the individual sequence of operation tests.

   c. Performance Tests.
      1) Performance tests are to be performed after the sequence of operation and verifications tests, and are focused on testing and verifying performance. Performance tests are typically witness by the CxA at a lower sample rate. An example is an irrigation system coverage test.

2. The CxA will develop FPT forms that contain:
   a. Specific step-by-step procedures to execute the test in a clear, sequential and repeatable format, including any control system point value or setpoint overrides required to simulate a test condition or sequence mode.
   b. The expected system response and acceptance criteria of proper performance with a Yes/No check box to allow for clearly marking whether or not proper performance of each part of the test was achieved.
   c. A section for recording actual system response, notes and comments.

3. Once the SRC forms are complete, the Trade Subcontractors shall execute the FPTs, with the FPTs witnessed by the CxA.
   a. The GC and Trade Subcontractors are responsible for ensuring all systems are installed, operating and performing per the requirements of the contract and design documents, and are ready for the FPTs.
   b. The Trade Subcontractors shall determine what level of pre-testing is appropriate in order to prepare for the CxA witnessed FPTs.
c. A percent sampling approach may be used for executing the FPTs of identical systems and equipment, to be defined in the Cx Plan and FPT forms.
d. The acceptance criteria for the FPT sampling shall be zero, meaning, any FPTs that do not pass shall require the Trade Subcontractor to resolve the issue for all applicable systems and equipment (even those specifically not in the original sample) and new sample rates selected for a re-test executed by the Trade Subcontractor and witnessed by the CxA. The CxA shall deem the FPTs acceptable after all FPTs, including re-tests, have passed and resolution of all issues completed.
e. The CxA will document the results of all FPTs on the associated FPT forms created by the CxA, unless indicated otherwise on the FPTs.

4. The Cx Plan will define any seasonal or deferred testing.

E. Cx Issues and Recommendations

1. Throughout the process, the CxA records Cx issues and recommendations on the Cx Log and distributes the Cx List to the team. The GC and Trade Subcontractors shall correct Cx issues and recheck or retest the system(s) without delay at no additional cost to the Owner. The CxA will verify the completion of the issues and recommendations, and make all amendments to the Cx Log.

F. Training Verification and Final Documentation

1. The GC shall submit a comprehensive Training Plan (with specific training agendas provided by the Trade Subcontractors) for review by the Design Professionals, CxA and Owner, prior to conducting any training. The Training Plan shall meet the specific requirements in the contract documents and specifications for each applicable system to be commissioned and the LEED Enhanced Commissioning requirements, and may include both operations and maintenance (O&M) staff training and building occupant training. The GC shall coordinate with the Owner and/or Owner’s Representatives, as needed, regarding any specific requirements for occupant training.

2. The CxA will verify completion of the training by witnessing some training sessions and receiving a copy of all training class sign-in sheets and any training materials / handouts, to be provided by the CxA or Trade Subcontractors.

3. The CxA will develop the Systems Manual (per the LEED requirements), including the current facility requirements, a preventative O&M plan and an ongoing Cx plan, with assistance from the GC and Trade Subcontractors.

4. The CxA will complete the Commissioning Report and all associated documentation for the Owner with assistance from the GC and Trade Subcontractors.

G. Post-Occupancy Warranty Phase Commissioning

1. The CxA will report any identified operational or performance issues (identified by the building O&M staff or warranty phase Cx activities) to the CxC via a Warranty Phase Cx Log for resolution by the GC and Trade Subcontractors during or prior to the end of the warranty period.

2. The Trade Subcontractors shall execute any defined seasonal or deferred FPTs, witnessed by the CxA.

3. No later than either 10 months after substation completion or two months prior to the expiration of the first 12-month warranty period of building occupancy, the CxA will return to the facility to interview facility O&M staff, walk the facility and review systems operation and trend data where applicable. Key representatives from the GC and Trade Subcontractors shall attend a site walk-through and meeting, as determined by the CxA.
1.7. COMMISSIONING TEAM

A. The Commissioning Team is responsible for performing the process and achieving successful commissioning results. The Commissioning Team is comprised of the following:

1. Owner and Owner’s Representatives
2. Commissioning Authority (CxA).
3. Design Professionals
4. General Contractor (GC)
5. GC’s Commissioning Coordinator (CxC)
6. Trade Subcontractors responsible for systems covered in this section include:
   a. Landscape Irrigation Contractor
7. Manufacturer Representatives supplying equipment, materials, components and controls for the systems to be commissioned.

1.8. RESPONSIBILITIES

A. General.

1. The Commissioning Team and all others involved in the commissioning process shall follow the Commissioning Plan, attend the commissioning kickoff meeting, and attend additional commissioning meetings as necessary.

B. Commissioning Authority (CxA)

1. See Section 01910, General Commissioning Requirements.

C. General Contractor:

1. See Section 01910, General Commissioning Requirements.

D. Trade Subcontractors – General Requirements:

1. Provide and submit for CxA review, the representative blank forms and plans for completing all IV, Startup, and PFCT tasks, including manufacturer’s installation checks and startup procedures. Electronic files are acceptable.
2. Provide any equipment and construction submittals and shop drawings, including detailed sequences of operation, and any other requested contract documentation for systems to be commissioned, as requested by the CxA. Electronic files are acceptable.
3. Attend commissioning meetings as directed by the CxA and GC’s CxC to facilitate the commissioning process.
4. Assign personnel with expertise and authority to act on behalf of the Trade Subcontractor and schedule them to participate in and perform assigned commissioning tasks.
5. Ensure that any required manufacturer factory tests are performed and provide the factory test data and results where required.
   a. Perform IV, Startup and PFCT tasks for all systems and equipment (no sampling), unless the contract or design documents allow for sampling of these tasks.
   b. Complete all IV, Startup and PFCT documentation clearly and legibly.
   c. Submit all completed IV, Startup and PFCT forms to the CxC and CxA, as part of completing the SRC forms, for review by the CxA.
7. Provide a schedule and access for the CxA to witness any equipment Startup and PFCT tasks. Notify the CxC and CxA at least 10 days in advance of Startup and PFCT tasks.
8. Ensure that any required manufacturer's representative field tests and on-site IV, startup and checkout of selected equipment are performed per the contract documents. Provide completed manufacturer documentation and commissioning forms for these activities to the CxC.

9. Address applicable Cx issues promptly. All IV, Startup and PFCT issues must be resolved before the FPTs can proceed.

10. Assist the CxA in preparing the FPT procedures, clarifying the operation and control of commissioned equipment where the specifications, control drawings or equipment documentation are not sufficient for writing detailed testing procedures.

11. Review the FPT procedures to ensure feasibility, safety and equipment protection, and provide necessary written alarm limits, setpoint changes and overrides to be used during the tests.

12. Setup any additional control system software points, global commands, overrides of any sensor values or relays, and overrides of any setpoints or schedules, to simulate certain conditions and operating modes, in order to conduct the FPTs.

13. Perform the FPTs, with the FPTs witnessed by the CxA. Provide at least 10 days advance notice to the CxC and CxA for scheduling the FPTs.

14. Prepare a training agenda for each training class for the equipment and systems to be commissioned.

15. Coordinate with the GC and Owner to schedule and plan training. Execute training of Owner's personnel per approved training agenda and schedule. Provide copies of training class sign-in sheets and materials / handouts.

16. Prepare O&M Manuals according to the Contract Documents. 

17. Assist the CxA in developing the Systems Manual, including providing as-built drawings, controls sequences, setpoints, single-line diagrams, etc., necessary for the Systems Manual.

E. Trade Subcontractors – Specific Irrigation Systems Requirements

1. In addition to the general Trade Subcontractor responsibilities outlined above, the Irrigation Systems Trade Subcontractor responsibilities during commissioning shall include, but are not limited to:

   a. Submit an Irrigation System Pressure / Leak Test Plan for all applicable irrigation systems, for review by the CxA, at least 4 weeks in advance of conducting any required tests. The Test Plan shall include the test methods, pressures and durations.

   b. Provide approved submittals, including shop drawings, control drawings (showing all control points and sensors), points list and detailed sequences of operation for each piece of equipment and system to be controlled (inclusive of any local, stand-alone system controls). The system sequence of operation shall fully describe their equipment components and functionality, including setpoints, failure modes and alarm functions. The detailed sequence of operation shall be provided regardless of the completeness and clarity of the sequences in the controls specification and/or drawings. Electronic files are acceptable.

1.9. SUBMITTAL REQUIREMENTS FOR COMMISSIONING

A. Trade Subcontractor Commissioning Forms. The Trade Subcontractors shall submit to the CxA all applicable representative, blank forms and plans for IV, Startup and PFCT tasks for the project (as listed in 1.8 Trade Subcontractor Responsibilities), at least 4 weeks in advance of performing any of these tasks.

1. The draft SRC forms issued by the CxA will list the required IV, Startup and PFCT forms and plans, required for this project. The Trade Subcontractor shall review the draft SRCs
to ensure all applicable, representative IV, Startup and PFCT forms and plans have been submitted for the CxA review.

2. The CxA will review these submitted commissioning forms including whether all project specific requirements are included.

3. The CxA may request additional data, changes and/or additions to these forms to confirm application prior to their use. If the Trade Subcontractor cannot submit sufficient forms, the CxA will provide forms based on the construction documents and specifications, manufacturer installation manuals and procedures, and/or industry standards or guidelines.

B. Training Agenda. The Trade Subcontractors shall develop a Training Agenda for each training session, per the requirements of the contract documents and specifications, and the LEED Enhanced Commissioning requirements, and may include both operations and maintenance (O&M) staff training and occupant training. The Training Agenda shall be included in the comprehensive Training Plan to be submitted by the GC for review by the CxC, Design Professionals, and/or the Owner (see Section 01910, General Commissioning Requirements). The GC and Trade Subcontractors shall coordinate to fully develop the comprehensive Training Plan with input from the Owner.

1. The Training Agenda for each training session shall include the following:
   a. equipment and/or systems covered;
   b. recommended attendees;
   c. proposed location;
   d. estimated duration;
   e. level of instruction to be provided and an outline of the training topics and subjects to be covered;
   f. list of any materials and handouts to be provided (or provided in advance);
   g. company to provide the training and the instructor’s name and qualifications.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1. MEETINGS, SCHEDULING AND COORDINATION

A. See Section 01910, General Commissioning Requirements.

3.2. DOCUMENTATION

A. The Trade Subcontractors have specific responsibilities for assisting in the development of equipment check, test and verification procedures and forms, and in performing and documenting commissioning tests, as directed by the CxC and as overseen by the CxA.

B. The Trade Subcontractors shall provide, wherever the Contract Documents require, system checks and testing, test reports, factory test data and reports, checklists, operational verifications and demonstration, etc., whether specified or not in the commissioning sections.
3.3. TEST EQUIPMENT

A. The Trade Subcontractor shall provide all test equipment in sufficient quantities to execute all Pre-Functional and Functional Performance Tests in an expedient fashion.

B. The test equipment shall be of industrial quality and suitable for testing and calibration with accuracy within the tolerance necessary to demonstrate system performance per the Contract Documents.

C. The test equipment shall have calibration certification per equipment manufacturer’s interval level or within one year if not otherwise specified. The calibration tags shall be affixed or certificates readily available for all test equipment.

3.4. SYSTEM READINESS: INSTALLATION VERIFICATION, STARTUP, PRE-FUNCTIONAL CHECKS & TESTS

A. The Trade Subcontractors shall conduct all startup procedures and tests without compromise to human or equipment safety. The GC and Trade Subcontractors shall be responsible for the liability and safety of conducting all startup, checks and tests.

B. The Trade Subcontractors shall clearly identify and list any issues and deficiencies resulting from the IV, Startup and PFCT tasks on the associated forms and immediately notify the CxA. The CxA will additionally document the issues on the Cx Log. Once issues and deficiencies are corrected and verified, the associated forms shall be updated and resubmitted, and any necessary field review, back-checks or re-tests witnessed by the CxA.

C. The CxC and Trade Subcontractors shall provide a minimum 10 days’ notice to the CxA for witnessing equipment Startup and PFCT tasks.

1. The sample rates for the CxA witnessing of irrigation system piping PFCT tasks, will be defined in the Cx Plan.

D. The GC and Trade Subcontractors shall ensure the completion of the SRC forms. Review and approval of the completed SRC forms by the CxA is required prior to conducting the FPTs.

3.5. FUNCTIONAL PERFORMANCE TESTS

A. The Trade Subcontractors shall perform all FPTs per the final FPT forms. The FPTs shall be witnessed by the CxA. The Trade Subcontractors may need to complete off hours or weekend work in order to complete the FPTs.

B. The CxA will document all testing results on the FPT forms.

C. As outlined in the Part 1 general commissioning process, a sampling approach shall be used for the FPTs of identical systems and equipment, as defined in the specification herein and/or the Cx Plan, with the specific systems and equipment selected by the CxA.

D. The Trade Subcontractors shall determine what level of pre-testing is appropriate in order to prepare for the CxA witnessed FPTs.

E. The CxC and Trade Subcontractors shall coordinate all FPTs with the CxA, and provide a minimum of 10 days’ notice prior to conducting each test.
F. The GC and Trade Subcontractors shall have responsibility for the liability and safety of conducting all functional performance tests.

G. The Trade Subcontractor executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. to execute the test according to the test procedures.
   1. The Trade Subcontractors shall provide any necessary control system global or system level commands and setpoint adjustments necessary to conduct the testing as called out in the FPT procedures.

H. At completion of the test, the Trade Subcontractor shall return all affected equipment and systems to their pre-test normal condition.

3.6. COMMISSIONING ISSUES, BACK-CHECKS AND RE-TESTS

A. When Cx issues are identified during testing, the CxA will discuss with the executing Trade Subcontractor and/or CxC and determine whether or not testing can proceed. The CxA may allow immediate correction of minor issues and deficiencies identified during testing. The Cx issue and any identified resolution will be documented on the test form in use in addition to the Cx Log.

B. The CxA will maintain and update the Cx Log, and document the issue resolution process. Copies will be distributed to the GC, Owner, and Trade Subcontractors as appropriate. The Trade Subcontractors shall provide updates and comments regarding issue status and resolution.

C. The Trade Subcontractors shall promptly correct all Cx issues. The responsible party shall correct the issue and inform the CxC and CxA of the resolution and completion date, and update the Cx Log accordingly (in the fields assigned for contractor updates).

D. The CxA will record completion on the Cx Log after a successful witnessed re-test, field review, back-check, verification obtained through appropriate documentation or photographs, or acceptance by the Design Professional or Owner. The CxC shall reschedule any applicable re-testing with the CxA and Trade Subcontractor. The Trade Subcontractor shall retest until achievement of passing performance or Owner acceptance of the noted issue.
   1. Where sampling is used for the PFCTs and FPTs, the results shall be deemed acceptable once all noted issues are resolved and any new sample tests or checks have passed.

E. Additional parties may require input during a dispute regarding a Cx Issue. Regardless of the validity or responsibility of the issue, the CxA will have the final interpretive authority on Cx issues and the Owner will have the final approval authority.

F. The CxA may recommend solutions to Cx issues. However, the GC and Trade Subcontractors ultimately have the burden of responsibility to solve, correct and perform required retests.

G. Back-checks, Verifications and Re-testing:
   1. The CxA will witness one (1) re-test or will perform one (1) field back-check or verification of any Cx issue.
   2. The CxA’s total onsite time for re-test witnessing and field verification or back-check of Cx issues will be limited to no more than 2 work days (full 8-hour work days) for all applicable systems in the commissioning scope.
   3. The Owner may back-charge the GC for any additional fees from the CxA, resulting from any additional re-testing or field back-checks or verifications beyond this allocated total time.
4. The CxC must provide a minimum 48 hours’ notice for scheduling any re-testing, though the CxA will attempt to accommodate a shorter timeframe if feasible.

5. Any required re-testing shall not be considered a justified reason for a claim of delay or for a time extension.

H. For any re-testing required, the CxA will determine if the entire test must be re-tested or if it is acceptable to re-test specific portions of the test that had failed.

3.7. DEFERRED & SEASONAL TESTING

A. Before or during the end of the first year warranty period, the Trade Subcontractor shall complete any seasonal or deferred testing, required per the design specifications and as defined in the Cx Plan. The Trade Subcontractors shall complete tests in the same manner as all other commissioning tests, including CxA witnessing.

B. The CxC and Trade Subcontractor shall coordinate with CxA and Owner and schedule all deferred and seasonal testing.

3.8. TRAINING VERIFICATION

A. The CxC and Trade Subcontractors shall coordinate and schedule the training for the Owner’s facility and operations personnel, and building occupants. The CxC shall ensure that training is completed per the requirements of the contract documents and specifications.

B. Trade Subcontractors responsible for specific equipment and system training shall submit to the CxC, a written training agenda for each training class for the equipment and systems to be commissioned. The GC shall submit a comprehensive Training Plan, including the specific training agendas, to Owner, Design Professionals and CxA for review and approval. See also Section 01910, General Commissioning Requirements.

C. The CxA will review the Training Plans for commissioning verification prior to conducting the actual training.

D. For verification of actual training conducted, the CxC shall submit to CxA ‘attendee signed’ attendance sheets for each training session conducted and a copy of any final training presentations or handout materials.

3.9. COMMISSIONING ACCEPTANCE, CLOSE-OUT AND REPORTING

A. Completion of the main commissioning activities (system readiness checks, functional performance testing, and training) shall be accomplished as a prerequisite for substantial completion. Completion of any re-testing shall be completed prior to final acceptance of commissioning.

B. After completion of the main commissioning activities and following review of the completed commissioning documents, test results and the current Cx Log with the Owner, the Owner will indicate whether they accept completion of the project construction phase commissioning or if not, the requirements for acceptance. Upon Owner acceptance, any remaining open Cx issues will be transferred to the warranty phase Cx Log for tracking resolution and completion as part of the warranty phase commissioning.
C. Upon completion of all commissioning activities, the CxA will prepare and submit to the Owner a Cx Report detailing all completed commissioning activities and documentation. The CxC shall support this effort by providing all GC and Trade Subcontractor commissioning documentation.

D. The CxA will complete a Systems Manual for the systems and equipment commissioned, following the LEED requirements, with assistance provided by the CxC and Trade Subcontractors. The Systems Manual will provide the operating staff the information needed to understand and optimally operate the commissioned systems. It will also include the current facility requirements, a high-level O&M plan, and an ongoing commissioning plan.

3.10. POST-OCCUPANCY WARRANTY PHASE COMMISSIONING

A. The Trade Subcontractors shall execute any defined seasonal or deferred FPTs, witnessed by the CxA.

B. The CxA will report any identified issues and recommendations to the CxC via a Warranty Phase Cx Log for review and resolution by the GC and Trade Subcontractors prior to the end of the warranty period, for any issues or recommendations identified either by the CxA or the Owner. The CxC shall work with the Trade Subcontractors and O&M staff to make corrections and adjustments as required to address the issues and recommendations.

C. Key representatives from the GC and Trade Subcontractors shall attend a near end of warranty commissioning review meeting, to be scheduled with the Owner’s facility staff and the CxA, no later than either 10 months after substation completion or two months prior to the expiration of the first 12-month warranty period of building occupancy.

   1. During this meeting, the operation of the systems will be discussed with the Owner’s staff, the results of any commissioning trend analysis will be reviewed and the warranty phase Cx Log will be reviewed. If needed, a walk-through of the systems with the Owner’s staff will be conducted.

   2. Next steps and actions items for any open Cx issues and recommendations will be discussed and documented via meeting minutes or a field report issued by the CxA. The intent is to resolve any open Cx issues prior to the end of the warranty phase.

D. After correcting noted Warranty Phase Cx issues, the CxC shall notify the CxA, and the CxA will back-check and verify resolution of the Cx issues and recommendations.

E. Issues identified during the warranty period will remain warranty phase Cx issues until satisfactory completion by Trade Subcontractors, even if the warranty period expires during the correction and back-check period.

END OF SECTION
SECTION 321132 - AGGREGATE BASE COURSE

PART 1 - GENERAL

1.1 SECTION INCLUDES

   A. Aggregate base.
   B. Lime stabilization.

1.2 RELATED SECTIONS

   A. Section 312300, Structural Excavation and Fill
   B. Section 321216, Asphalt Paving
   C. Section 320523, Portland Cement Concrete Paving

1.3 RELATED DOCUMENTS

   A. Geotechnical Report.
   B. Caltrans Standard Specifications:
      1. Section 26, Aggregate Bases.
   C. ASTM:
      1. D 1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.

1.4 DEFINITIONS


1.5 SUBMITTALS

   A. Follow Submittal procedure outlined in Division 0 – General Conditions and Division 1 – General Requirements.
   B. Submit material certificates signed by the material producer and the Contractor, certifying that that each material item complies with, or exceeds the specified requirements.

1.6 QUALITY ASSURANCE

   A. Conform to these Specifications and Section 19 of Caltrans Standard Specifications.
   B. Finish surface of the prepared subgrade to receive aggregate base, shall be as specified in
Section 31 23 00.

C. Finish surface of material to be stabilized prior to lime treatment shall be as specified in Section 24-1.04 of Caltrans Standard Specifications.

D. Finish surface of the stabilized material after lime treatment shall be as specified in Section 24-1.08 of Caltrans Standard Specifications.

E. Do not project the finish surface of aggregate base above the design subgrade.

F. Finish surface of aggregate base shall be 0 to 0.05-feet.

G. Finish surface of cement treated base shall be as specified in Section 27 of Caltrans Standard Specifications.

H. Percentage of compaction specified shall be the minimum acceptable. The percentage represents the ratio of the dry density of the compacted material to the maximum dry density of the material as determined by the procedure set forth in ASTM Designation D1557.

PART 2 - PRODUCTS

2.1 FILL MATERIAL

A. If fill material is required to restore the previously constructed subgrade to its proper elevation, provide structural fill material specified in Section 31 23 00.

2.2 AGGREGATE BASE

   1. Class 2, 3/4-inch Maximum: Section 26-1.02A.

2.3 LIME STABILIZATION

A. Lime Treat Material per Geotechnical recommendation and field investigation if required.

PART 3 - EXECUTION

3.1 SOIL STERILANT

A. Furnish and apply to areas indicated in accordance with Section 31 23 00.

3.2 AGGREGATE BASE

A. Watering, Spreading & Compacting: Section 26-1.035, 26-1.04 and 26-1.05 of Caltrans Specs
3.3 LIME STABILIZATION

A. Performing the stabilization shall conform with Geotechnical recommendations.

END OF SECTION
SECTION 321312 - SITE CONCRETE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide Portland cement concrete site work complete, including the following principal items:
   1. Retaining walls, stairs, seat walls.
   2. Curbs, walks and pavements, including aggregate bases.
   3. Footings for posts and structures.
   4. Integrally colored cast-in-place concrete

B. Related requirements specified elsewhere include:
   1. Section 312300, EXCAVATION & FILL
   2. Section 312305, STRUCTURAL EXCAVATION & FILL
   3. Section 321132, AGGREGATE BASE COURSE
   4. Section 334100, STORM DRAINAGE SYSTEMS

1.2 RELATED DOCUMENTS

A. Soils Reports: “Geotechnical Engineering Investigation Report, C-4016 New Allied Science Building, Contra Costa College, 2600 Mission Bell Drive, San Pablo, California.” Kleinfelder Project No.: 20181569.001A, dated: October 17, 2017, including:
   1. Addendum Letters No. 1 and No 2. Dated March 2 and March 14, respectfully.

B. Reference and Standards
   1. Perform work in accordance with all applicable laws, codes and regulations required by State of California.
   2. Reference to "Standard Specifications" shall mean the current Standard Specifications of the State of California, Business and Transportation Agency, Department of Transportation, CALTRANS.
   3. The American Concrete Institute (ACI): "Manual of Concrete Practice," Parts 1, 2 and 3.
   4. The American Concrete Institute (ACI): “Recommended Practice for Concrete Formwork” (ACI 347R)
   5. The American Concrete Institute (ACI): "Hot Weather Concreting", 305R-99
   6. The American Concrete Institute (ACI): Guide for Concrete Slab construction, 302.1R-07
   10. West Coast Lumber Inspection Bureau's “Standard Grading Rules No. 17” (WCLIB)
   11. Concrete Reinforcing Steel Institute (CRSI): “Manual of Standard Practice” and “Recommended Practice for Placing Reinforcing Bars”.
   13. Americans with Disabilities Act (ADA), Federal ADA/State of California Title 24 Standards.

C. Stipulations

1. Finish Surface Tolerance: 1/4-inch maximum variation in 10 feet.
2. At no point shall paving surface fail to drain.
3. Finish Concrete Surface Slip Resistance: Shall have a minimum slip resistance coefficient of 0.65 on concrete pavement with less than 5% slope and 0.8 on concrete pavement with more than 5% slope.
4. Walls retaining soil that retain 30 inches or more of soil shall include a subsurface drain behind wall per Section 68 of the Standard Specifications and as accepted by the Owner's Representative. Drain line shall be connected to storm drain system as accepted by Owner's Representative.
5. Walls retaining soil that retain 18 inches or more of soil shall receive Dampproofing per Caltrans Standard Specifications, Section 54.
6. Contractor shall pour adjacent slabs in a way that does not impact finish quality or construction (expansion) joint dimensional stability.

D. Testing and Inspection, per Section 014500.

E. Conform to ACI 318, Section 5.13 during hot weather and to ACI 318, Section 5.12 during cold weather.

F. Requirements of ACI 318 shall govern work, materials and equipment related to this Section; specifications herein set minimum results required, and references to procedures are intended to establish minimal guides.

G. The Contractor shall be responsible for quality of concrete in place and shall bear burden of proof that concrete meets minimum requirements. Contractor shall confirm that site soils do not contain elevated levels of sulfate that would require sulfate resistant concrete as outlined in Table 4.3.1 of the ACI 318 Building Code or Table 19B-A-3 of the Uniform Building Code. If the site soils contain elevated levels of sulfate, it is the Contractor's responsibility to request mixes that meet the aforementioned requirements.

H. Placing of concrete by means of pumping will be an acceptable method of placement providing that the Contractor can demonstrate that:

1. Specified concrete strengths will be met.
2. Equipment has a record of satisfactory performance under similar conditions and using a similar mix.
3. Trial batches have been successfully made.

I. Installer Qualifications: Concrete work shall be by firm with 5 years experience with work of similar scope and quality.

J. Formwork Design Criteria: Formwork shall conform to ACI 318, Section 6.1 and CBC Section 1906A.

1. Formwork:
   a. Shall prevent leakage or washing out of cement mortar.
   b. Shall resist spread, shifting, and settling.
   c. Shall reproduce accurately required lines, grades and surfaces within tolerances specified.
2. Safety: The Contractor shall be responsible for adequate strength and safety of all formwork including falsework and shoring.

3. Formwork allowable tolerances: Formwork shall produce concrete within tolerance limits recommended in ACI 318, Section 6.1, unless otherwise noted.

1.3 TESTS

A. The Owner will select a qualified testing laboratory to take samples for testing during the course of the work as considered necessary. Costs for such tests will be paid by the Owner. Contractor shall cooperate in arranging tests and shall be responsible for notifying the designated laboratory in sufficient time to allow taking of samples at time of pour.

B. Should tests show that concrete is below specified strength, Contractor shall remove all such concrete, as directed by the Owner. Full cost of removal of low strength concrete, its replacement with concrete of proper specified strength and testing, shall be borne by Contractor.

1.4 COORDINATION

A. Coordinate items of other trades. Contractor shall be responsible for the proper installation of all accessories embedded in the concrete and for the provision of holes, openings, etc., necessary to the execution of the work of the trades.

1.5 SUBMITTALS, per Section 013300.

A. Samples of all materials under this Division shall be supplied for testing as requested by the Owner.

B. Material certificates in lieu of material laboratory test reports when permitted by Engineer. Material certificates shall be signed by manufacturer and Contractor certifying that each material item complies with or exceeds requirements. Provide certification from admixture manufacturers that chloride content complies with requirements.

C. Submit color additive manufacturer’s color chart and sample chip(s), indicate color additive number and required dosage rate.

D. Submit full-scale mock-up (minimum 4’ by 4’) sample panels of all concrete finishes and color. The samples shall include curing compound if any is to be used, and include an expansion joint and a score joint, as indicated on the Drawings. Approved samples shall be kept at the job site to serve as a prerequisite for all finishes until acceptance of the Work.

E. Submit one pint samples of aggregate for exposed aggregate finished concrete paving in color range as specified.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Supply ready mixed concrete throughout. Batch, mix and transport in accordance with ASTM C-94, "Specifications for Ready Mixed Concrete."
B. Mix and deliver concrete in quantities that will permit immediate use only.

C. Indiscriminate addition of water for any reason will be cause for rejection of the load.

1.7 LEED REQUIREMENTS

A. Cast-in-place concrete shall contain a minimum of fly ash by weight as indicated in concrete mix design.

1.8 LEED SUBMITTALS

A. Submit certification in a letter indicating percentages by weight of fly ash content for cast-in-place concrete.

B. Submit product data highlighting percentages by weight of fly ash content for cast-in-place concrete.

C. LEED Requirement for cost information submittal requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Cement and aggregates shall have proven history of successful use with one another. Sources of cement and aggregate shall remain unchanged throughout work.

B. Mixes:
1. Ready-mixed concrete shall meet requirements of ASTM C94.
2. The Contractor shall perform tests or assemble the necessary data indicating conformance with specifications.
3. For each mix, submit data showing that proposed mix will attain the required strength in accordance with requirements of Caltrans Standard Specifications, Section 90.
4. Instruct Laboratory to base mix design on use of materials specified and approved by the Owner's Representative.
5. Mix design shall include compression strength test reports per CBC Section 1905A.6.3.
6. Insure mix designs will produce concrete to strengths specified and of uniform density without segregation.
7. If mix yield exceeds 1-cubic yard, modify mix design to no more than one cubic yard, without changing cement content.
8. Introduction of calcium chloride will not be permitted.
9. Mix design shall be in accordance with CBC Section 1905A.3.

C. Concrete Types (See Drawings for any other miscellaneous items not listed below):

<table>
<thead>
<tr>
<th>TYPE</th>
<th>28-DAY STRENGTH</th>
<th>AGGREGATE SIZE</th>
<th>FINISH &amp; COLOR</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slab on grade</td>
<td>3,000</td>
<td>1&quot; X #4</td>
<td>See Drawings</td>
<td></td>
</tr>
<tr>
<td>Site Walls</td>
<td>3,000</td>
<td>1/2&quot; X 1/4&quot;</td>
<td>See Drawings</td>
<td></td>
</tr>
</tbody>
</table>
### 2.2 FORMWORK MATERIALS

A. For Smooth Form-finished Concrete: Use Medium Density (or better) Overlaid Concrete Form Exterior (MDO), to provide continuous straight, smooth, exposed surfaces without grain patterns. Furnish in largest practicable sizes to minimize number of joints and to conform to a joint system as approved by Owner’s Representative.

B. Curbs may be formed with approved metal form systems.

C. Form Release Agent: Must not stain or otherwise adversely affect architectural concrete surfaces. “Nox-Crete Form Coating”; Industrial Synthetics Corp.’s “Synthex”; or equal.

D. Form Ties: Burke “Penta-Tie,” or equal, cone and rod type with 1-inch break-back.

### 2.3 REINFORCING MATERIALS

A. New, free of rust, Billet steel bars: Current ASTM designation A615.

B. Bar Reinforcement: ASTM A615.
   1. #3 and smaller: Refer to section 320523
   2. #4 and larger: Grade 60.
   3. Tie wire: #6 minimum, black and annealed.

C. Bar Reinforcement recycled content shall be a minimum of 75% recycled post consumer steel.

D. All reinforcing steel, bolts anchors, sleeves, etc. shall be securely anchored in place before concrete is placed. All reinforcing details, fabrication and installation shall conform to ACI Standard 315, latest edition, except as noted. Stagger all splices where practical and not otherwise detailed. Minimum concrete protection for reinforcement shall be as follows unless otherwise noted:
   1. 3” clearance where concrete is placed against the earth.
   2. 2” clearance where concrete is exposed to earth or weather but placed in forms.

E. Accessories: Metal and plaster spacers, supports, ties, etc. as required for spacing, assembling and supporting reinforcing in place. Legs of accessories to be of type that will rest on forms without embedding into forms. Galvanized metal items where exposed to moisture, or use other approved non-corrodible, non-staining supports.

### 2.4 CONCRETE MATERIALS

A. Portland Cement: ASTM C150, Type II, except if water or soil is high in sulfates use Type V Portland Cement as described above under Quality Assurance. Use one brand of cement throughout project.

<table>
<thead>
<tr>
<th></th>
<th>Quantity</th>
<th>Size</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curb &amp; Gutter</td>
<td>3,000</td>
<td>1&quot; X #4</td>
<td>See Drawings</td>
</tr>
<tr>
<td>Concrete Stairs</td>
<td>3,000</td>
<td>1&quot; X #4</td>
<td>See Drawings</td>
</tr>
<tr>
<td>Exposed Agg. Concrete</td>
<td>3,000</td>
<td>3/4&quot; X #4</td>
<td>See Drawings</td>
</tr>
</tbody>
</table>
B. Fly Ash: ASTM C618,08A.

C. Aggregates: ASTM C33, materials from established sources with proven history of successful use in producing concrete with minimum shrinkage.

D. Aggregate for seeded aggregate finish paving shall consist of 3/8" smooth, hard, fine-grained clean, river run pea gravel mix aggregate. Submit samples for approval as specified herein.

E. Aggregate for washed exposed aggregate finish paving shall consist of 3/4" by #4 smooth, hard, fine-grained clean, river run aggregate. Submit samples for approval as specified herein.

F. Water: Clear and potable, free from deleterious impurities.

G. Admixtures:
   1. Admixtures are optional; however, a water reducer or plasticizing admixture shall be included in the concrete mix and it must be compatible with color pigments where color pigments are required. Any proposed admixture shall comply with ASTM C494.
   2. Where more than one admixture is proposed, include statement from admixture manufacturer indicating that admixtures proposed for use are compatible, such that desirable effects of each admixture will be realized.
   3. Accelerating admixtures and admixtures containing more than 0.05 percent chloride ions are not permitted. If an accelerator is used, it shall be an non-chloride accelerator.
   4. Liquid admixtures shall be considered part of the total water.
   5. Refer to Color Additives/Pigments herein for color admixtures.

H. Color Additives/Pigments: Insoluble minerals, light fast, at least 95 percent passing #325 sieve complying with ASTM C979: Davis Colors, Los Angeles, CA (800) 356-4848; L.M. Scofield Co., Los Angeles, CA (800) 800-9900; or equal. Color(s) as shown on drawings.

2.5 CONCRETE MIXES

A. Concrete mixes shall be approved and shall be in accordance with Caltrans Standard Specifications Section 90. Unless otherwise noted, mix shall contain not less than 590 pounds of cementitious material per cubic yard (Class "2", 3,000 psi,) Type II Portland cement and a maximum aggregate blend of 1" by #4.

B. Cementitious Material: An intimate blend of type II Portland cement and fly ash. Cementitious material shall include 15% maximum fly ash by weight unless the strength is specified to be achieved on 7 or 14 days.

C. Matching existing colored concrete work: Mixes for matching existing colored paving shall be as required to match specified items on site using specified integral color pigments at required rates per 94 pounds of Portland cement. Submit integrally colored sample(s) per Submittals herein.

D. Lampblack: As supplied by batch plant for plain non-colored concrete work. Concrete for non-colored pavements shall be darkened by the addition of lampblack at the mixer. The proportion of lampblack or other approved colorant shall be that required to properly darken the concrete to reduce glare, and shall be subject to the approval of the Owner's Representative. Provide ¾ pound of lampblack per cubic yard of concrete unless required otherwise.
2.6  SPECIAL AGGREGATE FOR EXPOSED AGGREGATE FINISHES

A. Aggregate for exposed aggregate finished concrete paving shall be hard durable aggregate in a color range as accepted by the Owner’s Representative. Submit sample for approval.

2.7  ANCILLARY MATERIALS


B. Expansion Joint Material
   2. Caulked Expansion Joint: “Sonolastic Sealant Two-Part” as manufactured by Sonneborn-Contech, Building Products Division, Contech, Inc.; or approved equal. Joint caps or bond breaker tape to be as recommended by sealant manufacturer. Color shall match adjacent paving.

C. Dampproofing: Per CALTRANS Standard Specifications, Section 54, or approved equal.

D. Subsurface Drain behind Retaining-Type Walls: All concrete walls that retain 30 inches of soil or more shall include a subsurface drainage system to relieve water pressure in accordance with Section 68 of the CALTRANS Standard Specifications and as shown. If no subsurface drain is shown, provide corrugated polyethylene plastic tubing per 68-1.02K surrounded with an envelope of Class 2 permeable material in conformance to Section 68 “Subsurface Drains” of the Standard Specifications, 3/4 inch maximum without fines and wrapped with filter fabric per 68-1.028. Provide black colored rodent-proof slotted cap over exposed outfalls as accepted by Owner’s Representative.

E. Curing Materials for non-colored Concrete:
   1. Waterproof Paper: ASTM C171, Type 1.1.1.1, regular. Same as Sisalkraft Division of St. Regis Paper Co.’s “Orange Label”, or equivalent.
   3. Curing Compound: ASTM C309. Product: Sealtight 1100 Clear-Series by WR Meadows, Burke Azua Resin Cure by Edocol, or equal that will not discolor concrete or affect bonding of other finishes applied thereafter, and which restricts loss of water to not more than 0.500 grams per sq. centimeter of surface when tested per ASTM C156, “Test Method for Water Retention by Concrete Curing Materials.”

F. Curing Compound for Colored Concrete: Water-base acrylic type, free of permanent color, oil or wax, complying with ASTM C309: “W 1000” by Davis Colors, Los Angeles, CA (800) 356-4848; “Cureseal” semi-gloss by L.M. Scofield Co., Los Angeles, CA (800) 800-9900; or equal.

G. Grout: Premixed high strength non-shrink grout requiring only addition of water at the site. Burke’s “Non-Ferrous, Non-Shrink Grout”; Master Builders “Masterflow 928 Grout”, or equal.

H. Patching Mortar: Mix in proportions by volume of one part cement to two parts fine sand. Provide integrally colored patching mortar as required to match color and finish of colored concrete surfaces.
2.8 PERFORATED DRAIN PIPE

A. Polyvinyl Chloride (PVC) pipe and pipe fittings shall meet extra strength minimum of SDR-35 of the requirements of ASTM Specification D3034.

B. Perforated and non-perforated corrugated polyethylene pipe, 3- to 10-inch diameter, shall meet the requirements of ASTM D883 and ASTM F412, and shall conform to Section 68 of the Standard Specifications.

C. Corrugated polyethylene pipe fittings shall comply with all requirements of AASHTO M-252-85I for 3- to 10-inch diameter pipe. Couplings shall be split or snap-on type for perforated pipe and split couplings with gaskets for non-perforated pipe. Cutting pipe with integral couplings will not be allowed.

D. Corrugated polyethylene pipe and fittings manufactured by Advanced Drainage Systems, Inc., shall be considered the standard to determine compliance to this specification.

E. Inspection Tube Cap: Paint cap one coat chocolate-brown color using Flat, exterior grade latex paint as accepted by Owner's Representative.

2.9 FILTER FABRIC / PERMEABLE LANDSCAPE FABRIC

A. Polyester or polypropylene non-woven filter fabric with uniform fiber distribution by "Terra Bond" #1115, "Mirafi, Inc." #140N, or approved equal.

2.10 PERMEABLE DRAIN ROCK

A. Permeable drain rock used in subsurface drain installations to be Class 2 permeable material in conformance with Section 68 "Subsurface Drains" of the Standard Specifications; gradation to 3/4" maximum size. Submit Sample for approval.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Install all concrete work true to line and grade as indicated on the drawings.

B. Correct irregularities to the satisfaction of the Owner's Representative.

C. Plain non-colored, exposed concrete shall contain lampblack, approximately 3/4 pound of lampblack per cubic yard, as accepted by Owner's Representative.

D. The intent of the Grading Drawings is to provide positive drainage and to maintain slopes on walkways as required by the Americans with Disabilities act and California Title 24 throughout the project site. Notify the Owner's Representative immediately of any discrepancies between the Drawings and actual field conditions and/or conflicts between the design and Code requirements.
3.2 PREPARATION

A. Examine subgrades and installation conditions. Do not start concrete work until unsatisfactory conditions are corrected.

B. Provide subgrade preparation and the base material installation complete, including clearing, grading, excavation, filling and dewatering. Take every precaution to obtain a subgrade of uniform bearing strength, compacted to a minimum of 95% relative compaction as determined by the ASTM D1557 laboratory test procedure and in Sections 19 and 20 of the Caltrans Standard Specifications.

C. Subgrade shall be kept moist and shall not be allowed to dry out before placement of concrete. Place no material on muddy subgrade. Remove un-compactable material and replace with clean fill and compact as required.

D. Aggregate base, where indicated, shall be placed and compacted in conformance with Caltrans Standard Specifications 26-1.04 and 26-1.05.

E. Obtain approval of subgrade from Owner's Representative prior to placing steel and concrete.

3.3 FORMS

A. Forms shall be constructed in accordance with ACI 318, Section 6.1 and shall be of sufficient strength and sufficiently tight to prevent visible distortion or leakage of mortar and fines.

B. Forms for exposed surfaces shall be constructed to protect intended finish. Deflection of facing material between studs shall not exceed 0.0025 of the span. Facing material and pattern of joints shall be as approved by the Owner’s Representative.

C. For vertical surface of wall footings below grade, clean cut trench may be used in lieu of form if character of soil will permit installation without sluffing and width of concrete is increased at least 1 inch beyond indicated dimension of each face poured against earth.

D. Curb and pavement edge forms shall extend full depth of concrete and shall be coordinated with installation of planting root barriers where required. Curves shall be formed with flexible metal or wood made up of thin laminations. Curve forms shall extend one stake space straight beyond tangent point. Where curbs and pavement are adjacent to areas to receive root barriers, provide smooth uniform edges. Remove any excess concrete as required to allow installation of root barriers without gaps between curbs and/or pavement and barriers.

E. Maintain forms within the following tolerances.
   1. Top of Form: Plus or minus 1/8 inch in 10 feet and no abrupt variations; at required elevation to plus 3/8 inch.
   2. Face of Form: Plus or minus 1/4 inch in 10 feet longitudinal and no abrupt variations; perpendicular to surface plus or minus 1/8 inch.

F. Form Ties: Align form ties as accepted by Owner’s Representative. Obtain approval of form work from Owner's Representative prior to placing concrete.

G. Forms may be reused upon cleaning and coating with parting compound to ensure separation from concrete without damage.
H. After concrete is placed, the following minimum times shall elapse before removal of forms.
   1. Walls: 48 hours.
   2. Footing sides: 24 hours.
   3. Curbs: 1 hour

3.4 REINFORCEMENT

A. All concrete footings, walls, grade-beams shall be steel reinforced unless specifically noted to be “not reinforced.” If no reinforcement is shown, reinforce in same manner as that shown in similar places or as accepted by Owner's Representative.

B. Fabricate and place reinforcement as indicated on the Drawings and in accordance with ACI "Detailing Manual" SP-66. No reinforcement shall be placed prior to distribution of the approved shop drawings.

C. Secure reinforcement in position by suitable supports and by wiring at intersections with tie wire. Supports shall be of sufficient number and strength to resist crushing or displacement under full load. Metal shall not extend to surface of concrete.

D. At time of placing concrete, reinforcing shall be free of excessive rust, mill scale, or other bond reducing matter. Immediately before placing concrete, check and adjust position, support and anchorage.

3.5 CLEANING, PATCHING AND DEFECTIVE WORK

A. Where concrete is under strength, out of line, level or plumb, or shows objectionable cracks, honeycombing, rock pockets, voids, spalling, exposed reinforcement, signs of freezing, mismatched color, or is otherwise defective, and, in the Owner's Representative’s judgment, these defects impair proper strength or appearance of the work, the Owner's Representative will require its removal and replacement at the Contractor's expense.

B. Immediately after stripping and before concrete is thoroughly dry, patch minor defects, form-tie holes, honeycombed areas, etc., with patching mortar colored and textured to match concrete. Remove ledges and bulges.

C. Compact mortar into place and neatly file defective surfaces to produce level, true planes. After initial set, dress surfaces of patches mechanically or manually to obtain same texture as surrounding surfaces.

D. Rock Pockets:
   1. Cut out to full solid surface and form key.
   2. Thoroughly wet before casting mortar.
   3. Where the Owner’s Representative deems rock pocket too large for satisfactory mortar patching as described, cut out defective section to solid surface, and replace.

E. Cleaning
   1. Insure removal of bituminous materials, form release agents, bond breakers, curing compounds, if permitted and other materials employed in work of concreting that would otherwise prevent proper application of sealants, liquid waterproofing, and other delayed finishes and treatments.
2. Where cleaning is required, take care not to damage surrounding surfaces or leave residue from cleaning agents.

3.6 MIXING AND PLACING CONCRETE

A. Conform to applicable requirements set forth in Caltrans Standard Specifications Section 51-1.09 and Section 90.

B. Mixes for integrally colored concrete shall have pigment added early enough to ensure complete dispersal and uniform color, but not less than 15 minutes before placing.

3.7 JOINTS AND GROOVES IN FLAT WORK

A. Plane of joints shall be perpendicular to surface. Where new pavements join existing, joints shall align.

B. Sawn Contraction Joints:
   1. General: Provide where shown. Saw cut straight, true, and uniform, (1/8 -inch wide 1/4-inch-wide) and not less than 1/4 of slab thickness in depth, unless otherwise noted. Cut with a power saw fitted with an abrasive or diamond blade.
   2. Commence saw cutting operations after concrete has cured long enough to resist damage by the saw cutting operations and early enough to avoid random contraction cracks.
   3. Contractor shall coordinate form removal and sequencing of adjacent concrete placement to minimize unnecessary saw cutting of adjacent surfaces.
   4. Contractor shall plan for the use of varying types of saw cutting apparatus to provide acceptable finishes in areas limited in accessibility.
   5. Fill saw cut over-runs and inadvertent saw cutting of adjacent surfaces with cement mortar to match color and finish of sawn pavement.
   6. If the joint pattern is not shown, provide joints not exceeding 6 feet in either direction and located to conform to column centerlines, wall corners, etc. as accepted by Owner’s Representative.

C. Tooled Joints / Score Joints
   1. Form joints in fresh concrete using a jointer to cut the groove so that a smooth, uniform impression is obtained to 1/4 depth of pavement unless shown otherwise.
   2. All joints shall be struck before and after brooming. Tool concrete both sides of joint.
   3. If joint pattern is not shown, provide joints not exceeding 6 feet in either direction and located to conform to column centerlines, wall corners, etc. as accepted by Owner’s Representative.

D. Expansion Joints in Flat Work: Provided at the location and intervals as shown on the drawings, and at all locations where concrete paving abuts buildings, curbs, walls, columns, or other structures, and not more than 16 feet on center. Specified and shown joint material shall be placed with top edge 1/8" below the paved surface, and shall be securely held in place to prevent movement. Joint and other edges shall be formed in the fresh concrete using an edging tool to provide a smooth uniform impression. All edges shall be struck before and after brooming.
E. Sealed Joints: After the curing period, expansion joints shall be carefully cleaned and filled with approved joint sealant to just below adjacent paved surface in such a manner as to avoid spilling on paved surfaces or overflowing from joint.

3.8 JOINTS AND GROOVES IN WALLS

A. Provide control joints (weakened plane) in walls as shown on Drawings, and not to exceed 16 feet on center. Provide control joint both sides of wall opposite one another and connected across the top unless shown otherwise. If joint is omitted on top of wall, add bridging rebars to reduce cracking as accepted by Owner's Representative.

3.9 JOINTS AND FINISH OF STAIRS

A. General: Provide field scoring (control joints) of all exterior stair treads, slabs adjacent to the highest and lowest tread in a run of stairs, and at intermediate landings.

B. Scoring Layout: Provide matching pattern at all locations,

C. Finish: match adjacent paving

D. Stair Nosing Strip: Provide nosing strip as shown on drawings. Install per manufacturer’s recommendations. After installation remove dirt, grease, loose mortar, scale, salts, alkalies, and any other detrimental substances. Nosing Strip to conform to the following requirements

2. Setback from Sides: 2 inches maximum.
3. Overall Width including setback from nosing: 4 inches.

3.10 FINISHING

A. Flatwork and Curbs

1. Surface Finishes
   a. Float Finish (typical preliminary finishing for slabs to receive other finishes): The surface of the slab shall be screeded and all surface water and laitance removed. Floating shall be started as soon as the screeded surface has stiffened sufficiently. Floating shall be performed by hand using a wood float and shall be the minimum necessary to produce a relatively smooth, level, even-textured surface.
   b. Medium Broom Finish: Obtain by drawing a stiff bristled broom across a floated finish for a nonslip surface. Perform brooming while concrete is still wet enough to receive broom marks to match approved sample. Direction of brooming to be perpendicular to direction of work or as otherwise shown on the drawings.
   c. Brush Finish (typical for curbs): After the front form is removed, exposed surface shall be troweled smooth and then given a uniform light texture with fine brush parallel to line of curb, to match approved sample.
   d. Steel Trowel Finish: After surface water disappears and floated surfaces sufficiently hardened, steel trowel and retrowel to smooth surface. After concrete has set enough to ring trowel, retrowel to a smooth uniform finish free of trowel marks or other blemishes. Avoid excessive troweling that produces burnished areas.
e. Exposed Aggregate: Perform in as continuous an operation as possible, utilizing the same work crew to maintain continuity of finish.
   1) Use an surface retarder to expose the aggregate and surrounding matrix surfaces to match sample panel, as follows:
      a) Light Cut: approximately 1/16" depth
      b) Medium Cut: approximately 1/8" to 3/16" depth
      c) Heavy Cut: approximately 1/4" to 5/16" depth

3.11 DAMPPROOFING

A. Mop apply one heavy coat of asphalt dampproofing to soil side of retaining walls and planter walls from top of wall footing to a minus 2 inches below finished soil grade.

3.12 CURING

A. Cure non-colored exposed concrete in accordance with Caltrans Standard Specifications Section 90-7.

B. Cure colored exposed concrete using Curing Compound for Colored Concrete as specified herein.

C. When applying Curing Compound, apply after initial set of fresh concrete when bleed water has evaporated from surface using a "Hudson-type" airless sprayer in accordance with manufacturer’s specifications.

D. Only water or curing compounds which impart no permanent color or gloss shall be used for curing concrete.

3.13 CLEANUP: Per Section 017700.

END OF SECTION
SECTION 321216 - ASPHALT CONCRETE PAVEMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Prime coat.
B. Tack coat.
C. Asphalt concrete paving.
D. Asphalt concrete overlay.
E. Asphalt curbs.
F. Pavement grinding.
G. Adjusting manholes, valves, monument covers and other structures to grade.

1.2 RELATED SECTIONS

A. Section 32 11 32, Aggregate Base.

1.3 RELATED DOCUMENTS

A. ASTM:

B. Caltrans Standard Specifications.
   1. Section 39: Asphalt Concrete.
   2. Section 88: Engineering Fabrics.
   4. Section 93: Liquid Asphalts.
   5. Section 94: Asphaltic Emulsions.
1.4 DEFINITIONS

1.5 QUALITY ASSURANCE
A. Testing Agency: District’s Representative will engage a qualified independent testing agency to perform field inspections and tests and to prepare test reports.
   1. Testing agency will conduct and interpret tests and state in each report whether tested work complies with or deviates from specified requirements.

B. Additional testing, at Contractor’s expense, will be performed to determine compliance of corrected Work with specified requirements.

C. Thickness of Asphalt Concrete: In-place compacted thickness of asphalt courses will be determined according to ASTM D 3549.

D. In-Place Density: Samples of uncompacted paving mixtures and compacted pavement will be secured by testing agency according to ASTM D 979.
   1. Reference maximum theoretical density will be determined by averaging results from 4 samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
   2. In-place density of compacted pavement may be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
      a. One core sample may be taken for every 1000 sq. yd. or less of installed pavement, but in no case will fewer than 3 cores be taken.
      b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.

1.6 SUBMITTALS
A. Follow Submittal procedure outlined in Division 0 – General Conditions and Division 1 – General Requirements.

B. Job-Mix Designs: Certificates signed by manufacturers certifying that each asphalt concrete mix complies with requirements.

C. Material Certificates: Certificates signed by manufacturers certifying that each material complies with requirements.

1.7 PROJECT CONDITIONS
A. Environmental Limitations:
   1. Prime Coat: Minimum surface temperature of 60 deg F at application.
   2. Tack Coat: Minimum surface temperature of 60 deg F at application.
   3. Asphalt Concrete: Minimum atmospheric temperature of 50 deg F at application.
   4. Reinforcing Fabric: Air temperature is 50 deg F and rising and pavement temperature is 40 deg F and rising.
PART 2 - PRODUCTS

2.1 ASPHALT CONCRETE

A. Caltrans Standard Specifications Section 39, Type B.

B. Asphalt Materials:
   3. Tack Coat: Caltrans Standard Specification Section 94, SS1 or SS1h.


F. Sand: ASTM D 1073, Grade No. 2 or 3.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to support paving and imposed loads.

B. Proof-roll subbase using heavy pneumatic-tired rollers to locate areas that are unstable or that require further compaction.

C. Notify District’s Representative in writing of any unsatisfactory conditions. Do not begin paving until these conditions have been satisfactorily corrected.

3.2 PAVEMENT GRINDING

A. Clean existing paving surface of loose or deleterious material immediately before pavement grinding.

B. Grind conforms as indicated.

3.3 SURFACE PREPARATION FOR AGGREGATE BASE MATERIALS

A. General: Immediately before placing asphalt materials remove loose and deleterious material from substrate surfaces and ensure that prepared subgrade is ready to receive paving according to the Caltrans Standard Specification Section 39-4.01.

B. Prime Coat: Apply uniformly over surface of compacted-aggregate base according to the Caltrans Standard Specification Section 39-4.02. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure for 24 hours minimum.
1. If prime coat is not entirely absorbed within 8 hours after application, spread excess prime coat with hand tools and broadcast sand over surface to blot excess asphalt. Use just enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
2. Protect primed substrate from damage until ready to receive paving.

C. Tack Coat: Apply uniformly to all vertical surfaces against which asphalt concrete is to be placed, including existing surfaces of previously constructed asphalt or portland cement concrete paving and to surfaces abutting or projecting into new asphalt pavement, according to the Caltrans Standard Specification Section 39-4.02.
   1. Allow tack coat to cure undisturbed before paving.
   2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.4 SURFACE PREPARATION FOR PAVEMENT AT ASPHALT CONCRETE OVERLAYS

A. Pavement Irregularities: Level with asphalt concrete, Type B, No. 4 maximum.

B. Pavement Cracks:
   1. Less than ¼-inch wide: Clean of all dirt by compressed air jet, spray and seal with RS-1 asphaltic emulsion.
   2. Wider than ¼-inch: Clean of all dirt by compressed air jet, spray and seal with RS-1 asphaltic emulsion and skin patch.

C. Clean surface of all material, such as leaves, dirt, sand, gravel, water and vegetation prior to applying binder of paving asphalt to existing surface.

3.5 PAVEMENT REINFORCING FABRIC

A. Protect from exposure to ultraviolet rays until placed.

B. Reject rolls with broken or damaged cores, or factory wrinkled fabric that prevents wrinkle free placement.

C. Place with binder of paving asphalt in accordance with Section 39-4.03 of Caltrans Standard Specifications.

3.6 ASPHALT CONCRETE SPREADING AND COMPACTING EQUIPMENT

A. Spreading Equipment: Caltrans Standard Specification Section 39-5.01.


3.7 ASPHALT CONCRETE PLACEMENT

A. Place, spread and compact asphalt concrete to required grade, cross section, and thickness according to the Caltrans Standard Specification Sections 39-6.01, 39-6.02 and 39-6.03.
B. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.8 JOINTS

A. Construct joints to ensure continuous bond between adjoining paving sections according to the Caltrans Standard Specification Sections 39-6.01 and 39-6.02.
   1. Construct joints free of depressions with same texture and smoothness as other sections of asphalt course.
   2. Clean contact surfaces and apply tack coat.
   3. Offset longitudinal joints in successive courses a minimum of 6 inches.
   4. Offset transverse joints in successive courses a minimum of 24 inches.
   5. Compact joints as soon as asphalt concrete will bear roller weight without excessive displacement.

3.9 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact according to the Caltrans Standard Specification Sections 39-6.01 and 39-6.03.

B. Compaction Requirements: Average Density to be 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent nor greater than 96 percent.

C. Finish Rolling: Finish roll paved surfaces to remove roller marks while asphalt is still warm.

D. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while still hot, with back of rake or smooth iron. Compact thoroughly using tamper or other satisfactory method.

E. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh asphalt. Compact by rolling to specified density and surface smoothness.

F. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.10 ASPHALT CURBS

A. Construction: Place over compacted surfaces according to Caltrans Standard Specification Section 39-7.01 as specified for dikes. Apply a light tack coat prior to construction, unless pavement surface is still tacky and free of dust.

B. Shape: Place asphalt concrete to curb cross section indicated.

3.11 ADJUSTING MANHOLES, VALVES, MONUMENT COVERS AND OTHER STRUCTURES TO GRADE
A. Remove pavement, using vertical cuts, as needed to remove frame and provide for concrete collar. Do not damage adjacent pavement.
   1. Circular Covers: Cut circle with radius 6 inches larger than cover and concentric with cover.
   2. Rectangular Covers: Cut rectangle 6 inches larger than cover on all sides.

B. Install grade rings or blocking as needed to raise cover to finish grade.

C. Pour concrete collar:
   1. Bottom of Collar: Top of existing collar or 6 inches below top of proposed collar, whichever is at a higher elevation.
   2. Top of Collar: Bottom of existing asphalt pavement.
   3. Apply tack coat to all exposed surfaces.
   4. Fill excavation with asphalt concrete and, while still hot, compact flush with adjacent surface.

3.12 INSTALLATION TOLERANCES

A. Asphalt Pavement:
   1. Course thickness and surface smoothness within the tolerances specified in Caltrans Standard Specification Sections 39-6.01, 39-6.02 and 39-6.03.
   2. Total Thickness: Not less than indicated.

B. Trench Patch:
   1. Compacted surface: Within 0.01 foot of adjacent pavement.
   2. Do not create ponding.

C. Adjust Covers:
   1. Compacted surface: Up to 0.01 foot higher, and no lower, than adjacent pavement.
   2. Do not create ponding.

END OF SECTION
SECTION 323300 - SITE FURNISHINGS

PART 1 - GENERAL

1.1 1.1 DESCRIPTION
A. Furnish and install all site furnishings shown on drawings and specified in accordance with the manufacturer's instructions and as shown on the drawings and as specified.

B. Related requirement specifications elsewhere:
   1. Section 321312, SITE CONCRETE

1.2 REFERENCES
A. Perform work in accordance with all applicable laws, codes and regulations required by the City and the State of California.

B. Manufacturer's Instructions:
   1. Where required in the Specifications that materials, products, processes, equipment or the like to be installed or applied in accordance with manufacturer's instructions, directions or specifications, or words to this effect, it shall be constructed to mean that said application or installation shall be in strict accordance with printed instructions furnished by the manufacturer of the material for use under conditions similar to those at the job site.
   2. All site furnishings shall be anchored or otherwise secured to prevent movement, unless stated otherwise. Provide concrete footings, corrosion resistant clips, etc. as accepted by the Owner's Representative.

C. Reference Standards:

1.3 COORDINATION
A. Coordinate items of other trades. Contractor shall be responsible for the proper installation of all accessories embedded in concrete and for the provision of connections, holes, openings, etc., necessary to the execution of the work of the trades.

1.4 SUBMITTALS: Section 013300
A. All Product cut sheets, sample chips and required leveling spacers.

PART 2 - MATERIALS

2.1 SCULPTURAL SITE ELEMENT
A. Model: FLOR by Landscape Forms, Precast Concrete, Neutral color.
B. Model: MILENIO by Landscape Forms, Precast Concrete, Neutral color.


2.3 TRASH RECEPTACLE, Wabash FR500P 32-gallon, flare-top with side door. Perforated pattern, with LR310 receptacle liner & FT100 flat top lid with 8" diameter opening- inward slope. Freestanding.


2.5 TREE GRATE, 4’x8’ Jamison tree grate by Urban Accessories, 100% recycled grey iron w/ rust conditioner, 12” tree opening, Triangular end pieces to be custom, see plans. ADA compliant.

2.6 TRENCH DRAIN GRATE, 6"X18" 'Terrain' trench grate by Urban Accessories, 100% recycled grey iron with rust conditioner. Triangular end pieces to be custom, see plans. ADA compliant.

2.7 AREA DRAIN GRATE, 8"x8" drain grate by Urban Accessories, 100% recycled aluminum. ADA compliant.

2.8 BIKE RACK, Ultra Play Model 5000SM, Surface mount, Color; Blue

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install manufactured items in accordance with the manufacturer's instruction and as shown in the drawings and as specified herein.

B. Perform all work in accordance with all applicable laws, codes and regulations required by State of California

C. Set all work true and square, plumb and level. Remove and replace any wood that splits during or after erection until acceptance. Keep nailing neatly lined up.

D. Fabricate wood in as long pieces as practical unless otherwise indicated. End joints shall occur at supports. Keep all work clean, accurately cut, closely fitted and set to the required lines and levels. Blunt exposed edges by sanding or with plane.

E. Place washer under the head and nut of bolts where same bear on wood, except head of carriage bolt. Drill bolt holes same diameter as bolt.

F. Size bolts to fit flush with nuts. Countersink nuts and bolts as detailed.

G. Hammers with scored faces shall not be used in nailing.

H. Supply all miscellaneous metal units and install as specified herein under the Sections entitled "Miscellaneous Metalwork" and "Galvanizing." Hot-dip galvanize all metal fastenings, angles, etc., after complete fabrication.
I. Galvanized metal that is cut, damaged or modified after fabrication shall be immediately painted with Zinc-rich paint to prevent rusting.

J. Touch up paint any damaged surfaces to match original finish as accepted by Owner's Representative.

K. Set site furniture, level. Provide spacers under furniture to level as specified herein and acceptable to Owner's Representative.

L. Transport, store and handle precast units and manufactured items in a manner to avoid hairline cracks, staining or other damage. Store units free of the ground and protected from mud or rain splashes. Cover units, secure covers firmly, and protect the units from dust, dirt or other staining material.

3.2 SCULPTURAL SITE ELEMENT
   A. Install level and in accordance with the manufacturer's instruction and as shown.

3.3 TABLES & CHAIRS
   A. Install level and in accordance with the manufacturer's instruction and as shown. Surface mount.

3.4 TRASH RECEPTACLES
   A. Install level and in accordance with the manufacturer's instruction and as shown. Provide spacers under receptacles to level as specified and acceptable to Owner's Representative.

3.5 RECYCLING RECEPTACLES
   A. Install level and in accordance with the manufacturer's instruction and as shown. Provide spacers under receptacles to level as specified and acceptable to Owner's Representative.

3.6 TREE GRATES
   A. Install in accordance with the manufacturer's instruction and as shown.

3.7 TRENCH DRAIN GRATE
   A. Install in accordance with the manufacturer's instruction and as shown.

3.8 AREA DRAIN GRATES
   A. Install in accordance with the manufacturer's instruction and as shown.

3.9 BIKE RACKS
   A. Install in accordance with the manufacturer's instruction and as shown. Surface mount.

3.10 CLEANUP, per Section 017700.

END OF SECTION
SECTION 328400 - IRRIGATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work in this section consists of furnishing, layout and installing an irrigation system complete, including certification of irrigation system installation as required by the State of California Model Water Ordinance described herein.

B. Related work specified elsewhere includes:

1. Section 312300, EXCAVATION & FILL
2. Section 329000, PLANTING
3. Division 26 - ELECTRICAL (stub-out for controllers).
4. Section 320800, COMMISSIONING OF IRRIGATION SYSTEMS

1.2 CALIFORNIA MODEL WATER EFFICIENT LANDSCAPE ORDINANCE REQUIREMENTS

A. Contractor shall be familiar with and follow the State of California Model Water Ordinance, California Code of Regulations, Title 23 Waters, Division 2, Department of Water Resources, Chapter 2.7. Also, the Contractor is responsible to follow all local water ordinances.

B. Pursuant to the requirements of the California Model Water Efficient Landscape Ordinance, the Contractor shall submit a Certification of Installation to the Local Jurisdiction /water purveyor as described in the construction documents and these specifications. Certification shall at a minimum include the following documents:

PART 1. Project Information Sheet
PART 2. Certification of Installation according to the landscape documentation package.
PART 3. Irrigation Scheduling and Controller Programming
PART 4. Schedule of Landscape and Irrigation
PART 5. Landscape Irrigation Audit Report
PART 6. Soil Management/Analysis Report with verifying implementation, see Planting Specification for analysis requirements.

1.3 QUALITY ASSURANCE

A. Manufacturer's Specifications: Follow manufacturer's current printed specifications and drawings in all cases where the manufacturers of articles used in the Contract furnish directions covering points not specified or shown in the drawings.

B. Ordinances and Regulations: All local, municipal and state laws, codes and regulations governing or relating to all portions of this work are hereby incorporated into and made a part of these Specifications. Anything contained in these Specifications shall not be construed to conflict with any of the above codes, regulations or requirements of the same. However, when these Specifications and Drawings call for or describe materials, workmanship or construction of a better quality, higher standard, or larger size than is required by the above codes and regulations, the provisions of these Specifications and Drawings shall take precedence. Furnish without extra charge additional materials and labor required to comply with above rules and regulations.
C. References, Codes and Standards:
   1. State of California Model Water Efficient Landscape Ordinance
   2. California Environmental Quality Act (CEQA)
   3. Water Use Classification of Landscape Species (WUCOLS).
   6. CAL-OSHA, title 8, Subchapter 4-Construction Safety Orders and Subchapter 7-General Industry Safety Orders.
   8. California Plumbing Code (UPC) published by the Association of Western Plumbing Officials.
   9. NFPA 24, Section 10.4, Depth of Cover.
   10. Underwriters Laboratories (UL): Electrical wiring, controls, motors and devices, UL listed and so labeled.

D. Furnish without extra charge any additional material and labor when required by the compliance with all above mentioned codes and regulations, though the work be not mentioned in these specifications or shown on the drawings.

E. Experience: Assign a full-time employee to the job as supervisor for the duration of the Contract with a certified landscape technician, irrigation certification through CLCA or minimum of four (4) years experience in landscape irrigation installation.

F. Labor Force: Provide a landscape installation and maintenance force thoroughly familiar with, and trained in, the work to be accomplished to perform the task in a competent, efficient manner acceptable to the Owner's Representative.

G. Explanation of Drawings:
   1. Due to the scale of the Drawings, it is not possible to indicate all piping offsets, fittings, sleeves, etc., which may be required. Carefully investigate the conditions affected all of the work and plan accordingly, and furnish all required fittings. Install system in such a manner to avoid conflicts with planting, utilities and architectural features.
   2. Do not install the irrigation system as shown on the Drawings when it is obvious in the field that obstructions, grade differences or discrepancies in arc dimensions exist that might not have been considered in engineering. Bring such obstruction or differences to the attention of the Owner's Representative. Notify and coordinate irrigation Work with applicable contractors for location and installation of piping and sleeves through or under walls, pavement and structures. In the event this notification is not given, the Contractor shall assume full responsibility for any revision necessary.

H. Trench Interference with Tree Root Systems:
   1. Prior to trenching, layout main and lateral line locations within Drip Line of trees and review locations with Owner's Representative. Relocate any lines that may interfere with existing root systems to avoid or reduce damage to root systems as accepted by Owner's Representative.
   2. Mechanical Trenching is not allowed within dripline of existing trees to be protected except as approved by Landscape Architect

I. Coordinate plant locations with emitter locations.
1. Adjust plant locations in relation to the subsurface emitters as required to ensure that the plant roots receive the proper amount of water in order for it to thrive.
2. Coordinate planting and irrigation and provide hand watering of emitter irrigated and drip irrigated areas as required to maintain moist root zones until end of plant establishment period.

1.4 PROTECTION OF EXISTING STRUCTURES AND UTILITIES

A. The Drawings show, if applicable, existing above and below grade structures and utilities that are known to the Owner. Locate known existing installations before proceeding with construction operations that may cause damage to such installations. Existing installations shall be kept in service where possible and damage to them shall be repaired with no adjustment of Contract Sum. Verify with Owner if As Built drawings are available.

B. If other structures or utilities are encountered, request Owner's Representative to provide direction on how to proceed with the Work. If a structure or utility is damaged, take appropriate action to ensure the safety of persons and property.

C. Verify location of existing irrigation systems to be removed and/or replaced. Maintain any existing systems as required by the Drawings and Specifications, including temporary retention of systems necessary to maintain existing on site and adjacent planting.

1.5 SUBMITTALS, in accordance with Section 013300.

A. Materials List:
   1. Submit required copies of the cut sheets and a complete list of materials proposed for installation, along with any proposed substitutions clearly identified and obtain the Owner Representative's written approval thereof before proceeding. Use only accepted materials and items of equipment.
   2. List all materials by manufacturer's name and model number.
   3. Submit to Local Water Purveyor with copy to the Owner Certification of Installation as required by the State of California Model Water Ordinance.

B. Substitutions:
   1. If the Contractor desires to substitute a product, he shall list each item and note it as a "substitution" and provide the following information:
      a. Descriptive information describing its similarities to the specified product.
   2. If the product is approved and, in the opinion of the Owner's Representative, the substituted product does not perform as well as the specified product, the Contractor shall replace it with the specified product at no additional cost to the Owner.

C. Operations and Maintenance Manuals:
   1. Prior to the final acceptance of the irrigation system, furnish three (3) individually bound Operation and Maintenance Manuals to the Owner's Representative for use by the Owner. The manuals shall contain complete enlarged drawings, diagrams and spare parts lists of all equipment installed showing manufacturer's name and address. In addition, each Service Manual shall contain the following:
      a. Index sheet indicating the Contractor's name, address and phone number.
      b. Copy of the Landscape Irrigation Audit
c. Copy of the 12-month irrigation schedule and estimate of annual water consumption
d. Copies of equipment warranties and certificates.
e. List of equipment with names, addresses and telephone numbers of all local manufacturer representatives.
f. Complete operating and maintenance instructions in sufficient detail to permit operating personnel to understand, operate and maintain all equipment.
g. Parts list of all equipment such as controllers, valves, solenoids and heads.

D. Record Drawings:
1. Dimension the location of the following items from two (2) permanent points of reference such as building corners, sidewalks, road intersections, etc.:
   a. Connection to existing water lines/meter.
   b. Connection to electrical power.
   c. Gate valves.
   d. Routing of sprinkler pressure lines (a dimension at least every 100 feet and as required to identify all changes in direction and location).
   e. Remote control valves.
   f. Routing of control valves.
   g. Quick coupling valves.
   h. All sleeve locations.
   i. Routing of all control wiring.
   j. Include all invert elevations below 12”.
2. Deliver a reproducible record drawing to the Architect within seven (7) working days before the date of final review. Delivery of the record drawings shall not relieve the Contractor of the responsibility of furnishing required information in the future.

E. Controller Plan:
1. Provide one Irrigation Diagram plan in each controller housing. The plan shall show the area controlled by each valve in different colors and for orientation, any major permanent structure such as buildings and roads.
2. Charts to be waterproof and hermetically sealed between two pieces of transparent 10 mil thick plastic and installed in each controller on the door as accepted by the Owner's Representative no later than the time of the coverage test of the irrigation system.

F. Maintenance Material - supply the following tools to the Owner:
1. Three (3) sets of specialized tools required for removing, disassembling and adjusting each type of sprinkler, valve or other equipment supplied on this project.
2. Two (2) keys for each type of equipment enclosure.
3. Two (2) keys for each type of automatic controller.
4. Two (2) keys for each type of valve (including square type key for valves larger than 2")
5. Two (2) quick-coupler keys and matching hose swivels for each type of quick-coupling valve installed.
6. All lock keys shall be keyed alike.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Furnish and deliver materials in manufacturer's packaging, bearing original legible labeling.

B. The Contractor is cautioned to exercise care in handling, loading, unloading, and storing PVC pipe and fittings. All PVC pipe shall be transported in a vehicle which allows the length of the pipe to lie flat so as not to subject it to undue bending or concentrated external load at any
point. Any section of pipe that has been dented, cracked, or otherwise damaged shall be discarded and, if installed, shall be replaced with new piping.

1.7 SEQUENCING AND SCHEDULING

A. Acceptance: Do not install main line trenching prior to acceptance by Owner's Representative of rough grades completed under another Section.

B. Coordination: Coordinate with the work of other sections to insure the following sequence of events:
   1. Sleeves and Conduits: Installation of all sleeves and conduits to be located under paving and through walls prior to placement of those materials.
   2. Bubbler Heads: Install after placement of tree, but prior to backfill with planter soil mix.
   3. On-Structure Equipment: Install piping and risers after waterproofing is accepted.
   4. Sprinkler Head in Pots: Install riser and seal the penetration of the pot prior to backfill of pot with drainage materials and planter soil mix.
   5. Coordinate work schedule with Owner to avoid disruption of landscape maintenance of existing landscaping.
   6. Install piping prior to soil preparation (planting soil amendment installation).

1.8 WARRANTY, per Section 017836.

A. In addition to manufacturer's guarantees and warranties, work shall be warranted for one (1) year from date of final acceptance against defects in material, equipment and workmanship. Warranty shall also cover repair of damage to any part of the premises resulting from leaks or other defects in materials, equipment and workmanship to the satisfaction of the Owner.

B. Include a copy of the warranty form in the Operation and Maintenance Manual.

1.9 OPERATION

A. Routine: Inspect and adjust all spray heads and control valves including raising or lowering of spray head heights to accommodate plant growth and weather conditions.

B. Controller: Inspect regularly for power interruption and reset clock as required. Adjust station timing to accommodate changes in plant growth and weather conditions.

C. System Failure: Perform all repairs within one (1) operating period. Replacements to match removed products and materials in all respects. Report promptly all damage not resulting from Contractor's operations. Repair all damage caused by Contractor at no expense to Owner.

D. Climate Change: Set and program automatic controllers in response to seasonal requirements and requirements of newly planted materials.
PART 2 - PRODUCTS

2.1 PIPE

A. Pressure Main Line Pipe and Fittings: All PVC fittings shall bear the manufacturer's trademark name, material designation, size, applicable I.P.S. schedule and NSF seal of approval.

B. All main line pipe shall be solvent welded and shall be schedule 40 unless shown otherwise on the Drawings.
   1. PVC Pressure Rated Pipe: ASTM D2241 NSF approved Type I, Grade I, solvent welded PVC with an appropriate standard dimension ratio (S.D.R.).
   2. PVC Scheduled Pipe: ASTM D1785 NSF approved, Type I, Grade I, solvent welded PVC.
   4. Solvent Cement and Primer for PVC solvent-weld pipe and fittings: Type and installation methods prescribed by the manufacturer.
   5. Connections between Main Lines and RCVs: Schedule 80 PVC (threaded both ends) nipples and fittings unless required otherwise by local jurisdiction.
   6. Valves 2-inch and larger shall be flanged only.
   7. Copper pipe shall be Type K or Red Brass where threaded joints are required and Type L otherwise.

C. All lateral line pipe shall be solvent welded and shall be schedule 40 unless shown otherwise on the Drawings.

2.2 CONDUITS & SLEEVES

A. Sleeving shall be Schedule 40 PVC pipe sleeves and a minimum of two times the aggregate diameter of all pipes contained within the sleeve. Provide vertical sweep for all electrical conduit on each side of hardscape and terminate ends at 12" minimum depth and 12" from hardscape surface.

2.3 BACKFLOW PREVENTION DEVICE & ENCLOSURE, existing as shown on drawings.

2.4 CONTROLLERS(S):

A. Pedestal-mounted irrigation controller, as shown on drawings, and with the following minimum requirements.

B. Shall be weather – based and be compatible with rain shut off sensor.

C. Shall be user-friendly. The controller must have a minimum 20-character readout display describing actions or options, or a full visible panel of buttons, dials, or switches that control all different functions separately.

D. Shall have the ability to start a programmed sequence of valves a minimum of 5 times a day per program.

E. Shall have ability to easily and quickly change watering schedules due to change in weather.
F. Provide portable hand-held remote device compatible with controller and capable of operating all control valves.

A. Provide rain shut off device as manufactured by Control System manufacturer capable of shutting off all control valves. Locate in a location exposed to rain and hardwire to controller.

2.5 CONTROLLER GROUND

A. Provide each pedestal controller with its own ground rod. Separate the ground rods by a minimum of eight feet. The ground rod shall be an eight foot long by 5/8” diameter U.L. approved copper clad rod or as recommended by controller manufacturer. Install no more than 6” of the ground rod above finish grade. Connect #8 gauge wire with a U.L. approved ground rod clamp to rod and back to ground screw at base of controller with appropriate connector. Make this wire as short as possible, avoiding any kinks or bending. Install within pedestal housing base unless otherwise noted.

B. Provide each irrigation controller with its own independent low voltage common ground wire.

2.6 CONTROLLER ENCLOSURES

A. Verify correct equipment to fit the specified equipment, "Strong Box" available from John Deere, (800) 347-4272.

2.7 MASTER CONTROL VALVE

A. Master control valve shall be a 24 VAC, industrial type, solenoid control valve, Griswold 2000 series or equal. Valve shall be equipped with spring loaded packless diaphragm, cast iron body and bronze trim. The valve shall be of the normally open type and shall be equipped with four-prong (cross) flow control. Valve shall be slow closing without chatter settings or adjustment. Valve shall have a mechanical self-purging internal control system with tapered, serrated, scrubbing rod through diaphragm for positive, variable port opening and cleaning. No solenoid port screens. Valve solenoid shall be corrosion-proof, molded in epoxy to form one integral unit with no connection shunts and shall be 24 VAC, 3 watt maximum.

2.8 FLOW SENSORS

A. Compatible with controller and as recommended by controller manufacturer.

2.9 ISOLATION VALVE:

A. Valves 3 inches and smaller: 125 lb. WSP bronze gate valve with screw-in bonnet, non-rising stem and solid wedge disc, NIBCO T-113 K, or approved equal. Valves shall be line size.

B. Valves larger than 2”: shall have square nut stem and o-ring connections for key operation.
2.10 QUICK COUPLER VALVES:
A. Quick coupler valves shall be as listed on the Drawings with 10" diameter black box and black lid similar to isolation valve box described below.

2.11 BOX FOR ISOLATION & QUICK COUPLER VALVES
A. 10" diameter black plastic, Ametek, Brooks, Christy, Rain Bird with bolt down black lid marked "irrigation," or accepted equal. Avoid locating valve in paved areas. Provide H/20 Loading concrete box with bolt-down concrete lid if valve is located in paved area. Obtain location approval by Owner's Representative.

2.12 REMOTE CONTROL VALVE: As shown on Drawings and with the following minimum requirements:
A. Remote control valves shall be those normally manufactured for irrigation systems and shall have a slow, consistent speed of closure through entire closing operation, including last portion. To ensure this, the effective diaphragm working area/valve seating opening ratio must be a minimum 3 to 1.
B. Shall be mechanically self-cleaning to help prevent diaphragm or solenoid port plugging. To ensure this, the flush rod should be tapered to vary the size of the port opening as the diaphragm raises and lowers, thus allowing trapped material to escape. Rod is to be finished with a serrated surface to help scrub trapped material out. Screens not acceptable.
C. Shall have removable valve seat so valve can be repaired without removal from irrigation line.
D. Shall have ability to operate manually without the use of wrenches or special keys.
E. Shall have one-piece solenoid that attaches directly to valve without shunts or clips that can be lost.
F. Shall have cross top handle to adjust maximum travel of diaphragm to allow "tuning" of valve and closure.

2.13 BOX FOR REMOTE CONTROL VALVE
A. Rectangular black plastic valve box - Ametek, Carson, Christy, Rain Bird or accepted equal with non-hinged bolt down black colored lid marked "irrigation". Box body shall have knock outs. Do not saw cut body. The minimum size box is as shown on Drawings. Increase box size as required to fit. Valve box lids are to indicate the controller letter and station number of valve as accepted by Owner’s Representative. Also refer herein to required polyurethane tag at valve solenoid control wire under Control Wires. Locate the identification in center of the lid. Provide separate box for each valve. Provide H/20 Loading concrete boxes with bolt-down concrete lids for all valves that occur in paved areas.

2.14 CONTROL WIRES
A. Connections between automatic controllers and the solenoid-operated electric control valves shall be made with direct burial copper wire 14- AWG-UF 600 volt (minimum size). Pilot wires
shall be a color other than white, and shall be a different color for each automatic controller with
wires sharing a common trench. Common wires shall be white in color, with a different color
stripe for each controller with wiring sharing the same common trench. No stripe is required if
multiple controller wiring is not present.

B. Size of wire shall conform to the remote control valve manufacturer’s specification for control
wire sizes, but in no case shall the control wire be smaller than #14. Runs over 2,000 lineal feet
shall be #12- AWG-UF 600 volt copper wire.

C. All wire splices are to be made within a valve box, with a copper crimp-type connector, and a "3-
M" #DBY splice kit or Rain Bird “DBTWC25”.

D. Use continuous control wiring between controllers and remote control valves (no splices).

E. Provide polyurethane tag at valve solenoid control wire that shows the controller number and
station number. Also refer to valve box lid identification.

F. Provide a spare control wire in each RCV box for future.

2.15 SWING JOINTS

A. Sprinklers and Bubblers: Use Dura, Lasco, Rain Bird or equal pre-assembled swing joints with
O-rings.

2.16 Quick Coupling Valve: Dura 1-inch 1-A2-1-11-18 pre-assembled swing joint with O-rings and
Dura quick lock to receive stabilizing rod.

2.17 SHRUB & TREE BUBPLERS, as shown on drawings

2.18 DRIP EMMITTER IRRIGATION

A. Drip Manifold:

1. Pressure Regulator: Preset at 30 psi outlet pressure, ¾” female threaded inlet and outlet,
by RainBird, Torro or equal.
2. Emitters: Xeri-Bug (XB Series) by RainBird, Toro EZ Drip Series, or equal.
3. Flexible PVC: ASTM D2287 algae-resistant flexible PVC as recommended by
manufacturer of Drip Emitters.
4. Drip tubing: Conform to A. S. A. E. standards for minimum inside diameter and wall
thickness, Minimum 2% carbon black, Salco ¾” AR Drip PVC flexible drip hose, or equal.
5. ¾” Y-filter, 200 mesh.
6. Toro DL 2000 Air/Vacuum Relief Valves and In-line Spring Check Valves.
7. ¾” manual PVC ball valve with extra 3’ of hose coiled in valve box.
8. Drip system in accordance with “RainBird Xerigation Low-Volume Landscape Irrigation
Design Manual” and as shown on the drawings as required for a complete working
system.
2.19 IN-LINE DRIP IRRIGATION

A. As specified herein and as shown on the drawings and in accordance with manufacturer's recommendations. Provide all miscellaneous valves, filters fittings etc. required for a complete, operable system including the following:
   1. Rain Bird XFD/XFS/XFCV with “Copper Shield” technology. Drip system in accordance with “RainBird Xerigation Low-Volume Landscape Irrigation Design Manual” and as shown on the drawings as required for a complete working system.
   2. Pop-up operation indicator
   3. Air/vacuum relief valves
   4. Flush valves

B. Drip Valve Assembly: Size valve box large enough and deep enough to contain assembly and allow convenient access and easy removal of filter screen. Position filter pointed down, approximately 45 degrees.

C. Pressure regulator: Size regulator in accordance with flow rate. Do not over size. Use factory pre-set regulator at 30 PSI.

2.20 Y-STRAINER / BASKET STRAINER

A. Strainer upstream of remote control valves, Brass, 100 mesh.

2.21 RCV IDENTIFICATION TAGS:

A. Plastic or brass tags with valve number, approximately 2" by 2" with number imprinted, as accepted by Owner.

2.22 MISCELLANEOUS INSTALLATION MATERIALS

A. Solvent Cement and Primers for Solvent-weld Joints: Make and type approved by manufacturer(s) of pipe and fittings. Maintain cement proper consistency throughout use.

B. Pipe and Joint Compound: Permatex: Do not use on sprinkler inlet port.

2.23 MISCELLANEOUS EQUIPMENT/ACCESSORIES

A. Concrete for equipment pads (and thrust blocks if Bell-Type Pipe with O-Rings is required): Poured-in-place Class A concrete per Section 90 of the Caltrans Standard Specifications.

B. Sleeves and Conduits: See Drawings.

C. Key(s) for Quick-Coupling Valves:
   1. Type: Same manufacturer as Quick-Coupling Valve.

2.26 OTHER EQUIPMENT: As shown on Drawings and required for a fully functional irrigation system.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Sleeves and Conduits: Verify that all installed sleeving and conduits are undisturbed and are free of defects or errors introduced by the work of other sections.

B. Water Meter/Water Pressure: Test and verify that existing water pressure is the minimum pressure at maximum system g.p.m. to operate the irrigation system as indicated on the drawings.

C. Stub-outs: Verify that all stub-outs to be provided under another contract are correctly sized, located and installed as noted on Drawings.

D. Notification: Submit written notification to Owner's Representative within ten (10) working days of above inspections describing all acceptable and non-acceptable site conditions.

3.2 CONNECTIONS TO SERVICES

A. Provide and coordinate connection to water meter.

B. Provide and coordinate connection of irrigation controller to electrical power source.

3.3 INSTALLATION

A. Install irrigation system components in accordance with this Section, with the Drawings, with the manufacturer's recommendations, and with established industry standards. The Contractor shall do nothing that may jeopardize any manufacturer warranty.

B. Automatic Controller:
   1. General: Install with lock box cutoff switch per local code and manufacturer's current printed specifications. Provide each controller with its own independent low voltage common ground wire.
   2. Connection to Valves: Connect remote control valves to controller in clockwise sequence to correspond with station setting beginning with Stations 1, 2, 3, etc.
   3. Labeling: Affix controller letter (i.e., "A") on inside of controller cabinet door with minimum of one-inch (1") high permanent letter.
   4. Irrigation Diagram: Affix a non-fading, waterproof copy of irrigation diagram to cabinet door below controller name. Irrigation diagram to be sealed between two plastic sheets, 20 mil. minimum thickness. Use a legible reduced copy of the Record Drawing for the irrigation diagram clearly showing all valves operated by the controller, station, number, valve size, and type of planting irrigated. Color code area operated by each valve.

C. Control Wiring:
   1. General: Install control wires in common trenches with sprinkler mains and laterals wherever possible. Lay to the bottom side of pipe line. Provide looped slack at valves. Snake wires in trench to allow for contraction of wires. Tie wires in bundles at 10 ft. intervals.
2. Extra Length: Provide 30 inches (30") extra control wire at each remote control valve splice to facilitate the removal of the remote control bonnet to finish grade without cutting wires.
3. Spare: Install one unconnected spare control wire running from the controller through each intermediate control valve box.
4. Size: Minimum size of wire is to be determined strictly by the manufacturer's current printed specifications for remote control valves, but not smaller than #14.
5. Detection Wire: Install a bare #12 copper wire or greater on top of the PVC supply line for the purpose of possible future mine detection search. Install the control wires on the bottom of the PVC supply line with electrical tape every ten feet (10').
6. Splicing: Crimp control wire splices at remote control valves. Seal with specified splicing materials. In-line splices will be allowed only on runs exceeding 2500 feet and only in junction boxes.

A. Rain Shutoff Switch:
1. Install switch in area not affected by irrigation or rain shadow. Provide wires in rigid conduit as accepted by Owner's Representative.

B. Excavating and Trenching:
1. Prior to trenching, layout main and lateral line locations within Drip Line of trees and review locations with Owner's Representative. Relocate any lines that may interfere with existing root systems to avoid or reduce damage to root systems as accepted by Owner's Representative.
2. Dig trenches wide enough to allow a minimum of three inches (3") between parallel pipe lines. Provide a minimum cover from finish grade as follows:
   a. 24-inches Deep: Over pipe on pressure side of irrigation control valve, control wires and quick-coupling valves.
   b. 36-inches Deep: Over all pipe and pipe sleeves under roadways, parking lots, entrance to parking lots and Fire-Access Lanes per NFPA 24, Section 10.4.4.
   c. 18-inches Deep: Over pipe on non-pressure side of irrigation control valve.
   d. Direct Burial PVC Piping Under Pavement: Provide a minimum of 4 inches of sand backfill on all sides and 24 inches cover to bottom of paving.
   e. On-Structure: Protect waterproofing with 2-inch layer of planting soil mix or as otherwise detailed.

C. Conduits and Sleeves:
1. Coordination: Provide conduits and sleeves and coordinate installation with other trades.
2. Extent: Install conduits and sleeves where control wires and pipes pass under paving or through walls as shown on Drawings. Extend twelve inches (12") beyond edges of paving and walls and cap ends until ready for use.

D. Pipeline Assembly:
1. Install pipe and fittings in accordance with manufacturer's current printed Specifications.
2. Clean all pipes and fittings of dirt, scale and moisture before assembly.
3. Solvent-welded Joints for PVC Pipes:
   a. Solvents: Use solvents and methods specified by pipe manufacturer.
   b. Curing Period: Minimum of one (1) hour before applying any external stress on the piping and at least 24 hours before placing the joint under water pressure.
4. Threaded Joints for Plastic Pipes:
   a. Use Permatex on all threaded PVC fittings except sprinkler heads and quick coupler valve ACME threads.
b. Joining: Use strap-type friction wrench only. Do not use metal-jawed wrench. Assemble finger tight plus one or two turns.

5. Laying of Pipe:
   a. Bedding On-grade: Remove from trench all rocks or clods. Bed pipe in at least 2 inches of soil excavated from trench. Backfill on all sides of piping to provide a uniform bearing.
   b. Snaking: Snake pipe from side to side of trench bottom to allow for expansion and contraction. Minimum allowance for snaking is one (1) additional foot per 100 ft. of pipe.
   c. Moisture Restrictions: Do not lay PVC pipe when there is water in the trench. Do not assemble PVC pipe unless the pipe is dry.

E. Closing of Pipe and Flushing of Lines:
   1. Capping: Cap or plug all openings as soon as lines have been installed to prevent entrance of materials that would obstruct the pipe. Leave in place until removal is necessary for completion of installation.

F. Detection Wire and Warning Tape:
   a. Install a bare #12 copper wire or greater on top of the PVC supply line for the purpose of possible future mine detection search.

G. Control Valves:
   1. Install in valve boxes where shown on Drawings and group together where practical. Install box flush with finish grade, not necessarily level. If valve occurs in drainage swale, relocate out of drainage swale as approved by Owner's Representative.
   2. Where two or more valves are installed adjacent to each other, provide at least six inches (6") separation. Align boxes in a row, perpendicular with pavement edge.
   3. Permanently mark valve box lid with 2" black valve number and controller letter or with numbered metal tag inside box as approved by Owner's Representative.
   4. Refer to control wiring for required spare wire in each valve box.

H. Install “Y”-Strainer upstream of remote control valves at backflow preventer with two pressure gauges, one upstream and one downstream of each strainer/filter.

I. RCV Identification Tags:
   1. Install in remote control valve box as recommended by manufacturer and as accepted by Owner's Representative.

J. Bubblers:
   1. Coordinate installation with planting contractor to insure timely and proper placement of heads at new planting.

K. In-Line Drip Irrigation
   1. Coordinate plant locations with emitter locations. Refer to QUALITY ASSURANCE herein.
   2. Coordinate hand watering of emitter irrigated and drip irrigated areas. Refer to QUALITY ASSURANCE herein.
   3. Coordinate emitter spacing with planting types and plant spacing as accepted by Landscape Architect. Install emitters at uniform **18 inches** on center maximum and 2 to 4 inches deep, except where emitter spacing and depth is shown otherwise.
4. In Turf in raised (podium) planters and similar sandy soil planting areas, install emitters at uniform 12 inches on center maximum and 3 inches deep, except where emitter spacing and depth is shown otherwise.
5. Adjust spacing on slopes to prevent over watering at base of slopes. Install system in accordance with manufacturer’s recommendations and as shown on the Drawings as required for a complete working system.
6. Provide air/vacuum relief valves at all high points on systems.
7. Provide filter as shown and as recommended by emitter manufacturer.
8. Tape pipe ends during installation and do not allow dirt or debris to enter pipe.
9. Use emitter line with the specified emitter flow rate and emitter spacing. Assemble dripper line to allow water to flow continuously and directly, with no dead ends or dead end loops between control valve and flush valve.
10. Use fittings at sharp bends and do not allow dripper line to kink.
11. Install emitter line around perimeter of planter not more than 3 inches off edge for ground cover and turf, 18 inches maximum for shrub planting.
12. Adjust alternate rows so emitters are spaced in a triangular pattern.
13. Collect water from multiple dripper lines and convey the water to automatic line flush valve.
14. Install flush valve at end(s) of collector laterals so that entire system will flush and be free of dirt and debris.
15. Flush valves shall be open when water is turned on for the first time and after a break in the main or lateral lines. Extend collector lateral as required and locate flush valve at convenient accessible location.
16. Flush the systems weekly through the first month of the maintenance period.
17. Thoroughly saturate soil prior to planting. Provide additional surface watering as required to keep plant root systems moist during planting establishment period.

L. Drip Emitter Irrigation:
1. Install system in accordance with “RainBird Landscape Irrigation Design and Specifications Xerigation Products and Details” or equal and as shown on the Drawings as required for a complete working system.
2. Install Toro DL 2000 Air/Vacuum Relief Valves at high points in system.
3. Install manual PVC ball valve with extra 3’ of hose coiled in valve box at end(s) of collector laterals so that entire system will flush and be free of dirt and debris.
4. Install a continuous PVC irrigation mainline warning tape 12” above the supply line.

3.4 MISCELLANEOUS EQUIPMENT

A. Install miscellaneous equipment with concrete footings, brackets, etc., as required and as recommended by manufacturer.

3.5 FIELD QUALITY CONTROL

A. Testing of Irrigation System:
1. Make hydrostatic tests with risers capped when welded PVC joints have cured at least 24 hours. Center load piping with backfill to prevent pipe from moving under pressure. Keep all couplings and fittings exposed.
2. Install two (2) pressure gauges at opposite ends of main line system. Pump system up to a minimum of 125 psi the day preceding the scheduled test and verify that pressure is holding. Inspect system early following day and immediately notify Owner’s Representative if the test confirmation must be postponed.
3. Apply continuous static water pressure of 125 psi in accordance with Caltrans Standard Specifications Section 20-5.03H, except after a drop in pressure (5 psi maximum), then the pressure must stabilize and remain stable for a one (1) hour minimum period before acceptance of the test.

4. Leaks detected during tests shall be repaired and test repeated until system passes tests at no additional cost to Owner.

B. Irrigation Audit Report with Certificate of Completion

1. Per the requirements of the California Model Water Efficient Landscape Ordinance, the Contractor shall perform an irrigation audit and provide a report with certificate of completion to the local agency that may include, but is not limited to: inspection, system tune-up, system test with distribution uniformity, reporting overspray or run off that causes overland flow, and preparation of an irrigation schedule. Irrigation audits shall be conducted by a CLIA Certified landscape Irrigation Auditor by the Irrigation Association. Operation of the irrigation system outside the normal watering window is allowed for auditing and system maintenance.

C. Adjustment of the System:

1. Flush and adjust all sprinkler heads for optimum performance and to prevent overspray onto walks, roadways and buildings. Adjust the arc and radius as applicable.

2. Include as a part of the work any nozzle changes or arc adjustments necessary due to daytime windy conditions during grass establishment period. After grass has been established and watering can be performed during calm early morning or evening hours, make any required adjustments to nozzles and arcs.

3. Set all sprinkler heads perpendicular to finished grades unless otherwise noted on the drawings.

4. When the landscape sprinkler system is completed and before planting, perform a coverage test in the presence of the Owner's Representative to determine if the water coverage for planting areas is adequate.

5. Test controllers individually in the presence of the Owner's Representative and the Landscape Architect. Demonstrate that all control valves operate electronically. Provide vehicles and radio equipment as necessary to expedite this process.

6. Demonstrate to Owner's Representative that irrigation scheduling programmed into controller is adequate for plant requirements without causing runoff, and that scheduling capacities of controller are utilized.

3.6 IRRIGATION SCHEDULING AND CONTROLLER PROGRAMMING

A. Per the requirements of the California Model Water Efficient Landscape Ordinance All irrigation schedules and programs shall be developed, managed and evaluated to utilize the minimum amount of water required to maintain plant health.

B. Irrigation controller Scheduling and Programming Parameters to be conducted by a CLCA Certified Irrigation manager and submitted to the local agency as part of the Certificate of Completion.

C. Parameters used to set the automatic controller shall be developed for each of the following:

1. Plant establishment period
2. Established landscape period
3. Temporary irrigated area (if applicable)

D. Each irrigation schedule shall consider for each station all of the following that apply:
1. Irrigation interval (days between irrigation)
2. Irrigation run times (hours or minutes per irrigation event to avoid runoff)
3. Number of cycle starts required for each irrigation event to avoid runoff
4. Amount of applied water scheduled to be applied on a monthly basis
5. Application rate setting
6. Root depth setting
7. Plant type setting
8. Soil type
9. Slope factor setting
10. Shade factor setting
11. Irrigation uniformity or efficiency setting

E. Total annual applied water shall be less than or equal to Maximum Applied Water Allowance (MAWA). Actual irrigation schedules shall be regulated by automatic irrigation controllers using current reference evapotranspiration data (CIMIS or soil moisture sensor data).

3.7 BACKFILL AND COMPACTING

A. General: After system is operating and required tests and reviews have been made, backfill excavations and trenches with clean soil, free of debris.

B. Backfill for All Trenches: Regardless of the type of pipe covered, compact to minimum 95% density under pavements and 85% under planted areas.

C. Finishing: Dress off areas to finish grades. Re-dress any areas which subsequently settle.

D. Owner's testing agency will test backfill compaction in areas under paving.

3.8 MAINTENANCE

A. The entire sprinkler irrigation system shall be under full automatic operation for a period of 2 days prior to any planting.

B. The Owner's Representative reserves the right to waive or shorten the operation period.

C. Maintain/repair system for full duration of plant maintenance period.

3.9 REVIEWS PRIOR TO ACCEPTANCE

A. Notify the Owner's Representative in advance for the following reviews, according to the time indicated:
   1. Supply line pressure test and control wire installation - 72 hours.
   2. Coverage and controller test - 72 hours.
   3. Final review - 7 days.

B. No reviews will commence without record drawings, without completing previously noted corrections, or without preparing the system for review.
3.10 FINAL REVIEW AND CLEANUP, per Section 017700.

A. Operate each system in its entirety for the Owner's Representative at time of final review. Any items deemed not acceptable by the Owner's Representative shall be reworked to the complete satisfaction of the Owner's Representative.

B. Provide evidence to the Owner's Representative that the Owner has received all accessories and equipment as required before final review can occur.

C. Final acceptance and start of warranty period will occur no earlier than the end of the plant maintenance period.

D. For time of final review, Contractor shall arrange a meeting with the Owner's maintenance personnel to demonstrate the operation of the irrigation systems automatically in order to verify acceptance and to familiarize the maintenance personnel with the system and recommended programming.

END OF SECTION
PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide planting work and planting maintenance complete as shown on the drawings and as specified including staking and layout of the landscaping, including soil sampling as required by the State of California Model Water Ordinance.

B. Related work specified elsewhere includes:

   1. Section 311200, SOIL STRIPING & STOCKPILING
   2. Section 311001, PLANT PROTECTION
   3. Section 312300, EXCAVATION & FILL
   4. Section 328400, IRRIGATION

1.2 QUALITY ASSURANCE

A. Reference Standards:

   1. All local, municipal and state laws, codes and regulations relating to all portions of this work are to be incorporated as part of these Specifications. These specifications shall not be construed to conflict with any of the above codes, regulations or requirements. The Specifications and Drawings shall take precedence when they call for materials, workmanship or construction of a better quality or higher standard than required by the above mentioned codes and regulations. Furnish without extra charge additional materials and labor required to comply with above rules and regulations.
   2. State of California Model Water Ordinance
   3. Public utility agency having jurisdiction over the project work.
   7. US Composting Council Compost Analysis Program (CAP)
   8. US Composting Council (USCC) Seal of Testing Assurance (STA) program.
   10. Manufacturer's recommendations.

B. Qualifications:

   1. Experience: Assign a full-time employee to the job as foreman for the duration of the Contract who is certified landscape technician, certification through CLCA or minimum of four (4) years experience in landscape installation and maintenance supervision, with experience or training in turf management, entomology, pest control, soils, fertilizers and plant identification
   2. Labor Force: Provide a landscape installation and maintenance force thoroughly familiar with, and trained in, the work necessary to complete the tasks described herein in a competent, efficient manner acceptable to the Owner.

C. Requirement
1. Site Visit: At beginning of work, visit and walk the site with the Owner's Representative to clarify scope of work and understand existing project/site conditions.

2. Supervision: The foreman shall directly supervise the work force at all times and be present during the entire installation. Notify Owner's Representative of all changes in supervision.

3. Identification: Provide proper identification at all times for landscape maintenance firm's vehicles and a labor force uniformly dressed in a manner satisfactory to Owner's Representative.

4. Protect all existing and new plants from construction activities, deer & rodents: Contractor shall be responsible for protection of all planting per Part 3.

D. Plant Material Standards:

1. Quality and Size of Plants: Conform to the State of California Grading Code of Nursery Stock, No. 1 grade. Use only nursery-grown stock which is free from insect pests and diseases.

2. Comply with federal and state laws requiring inspection for plant diseases and infestations. Submit inspection certificates required by law with each shipment of plants, and deliver certificates to the Owner. Obtain clearance from the County Agricultural Commissioner as required by law, before planting plants delivered from outside the County in which planted.

E. Soils & Amendment Testing

1. All soils & amendments to be tested for agricultural suitability by one of the following accredited soil testing laboratory (or approved equal). Components of the test shall include all major nutrients, pH, salinity, boron, sodium, micronutrients, copper, zinc, manganese and iron, adsorption rate, organic content and texture. The laboratory report shall include recommendations for adjusting fertilizer and amendment quantities.

   Waypoint Analytical, Inc.
   1101 South Winchester Blvd, San Jose CA 95128; (408-727-0330)

2. Upon approval of the laboratory's report by the Landscape Architect, the recommendations in the report shall become a part of the Specifications and the soil preparation procedures, quantities of soil amendment, fertilizer and other additives shall be adjusted to conform with the report at no additional cost to the owner. Note that there is a minimum quantity of organic amendment specified elsewhere in this specification section.

3. Significant issues with soil quality will require soil to be retested in the locations identified on Soil Analysis Plan, prior to proceeding with plant installation, to ensure that the recommendations in the report have been followed and the In-Situ Topsoil is agriculturally suitable as described in Part 2.

1.3 DEFINITIONS

A. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms. Subsoil is defined as either existing site soil located below the topsoil prior to construction activities, or select fill used for rough grading during construction. Subsoil cannot be considered for use as planting soil.
1. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil," but in disturbed areas such as urban environments, the surface soil can be subsoil.

2. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects larger than 2 inches (50 mm) in diameter; and free of weeds, roots, toxic materials, or other non-soil materials.

3. Planting Soil: Approved existing topsoil or imported planting soil, meeting the requirements herein. Subsoil cannot be considered for use as planting soil.

1.4 SUBMITTALS, per Section 013300.

A. The following shall be submitted to the landscape architect for approval prior to the installation of landscape materials and products.

B. Manufacturer’s Technical data sheets for fertilizers, turf, and all other products and materials listed herein.

C. Manufacturer’s technical data sheets for amendments. Reports to be dated no more than 3 months prior to soil preparation.

D. 1-pint samples of imported soils, organic amendments/compost, mulches, and stones.

E. Submit planting soil and organic amendment laboratory reports a minimum of [3] weeks prior to beginning soil prep. See below for required soil analysis reports.

F. Topsoil stripping and stockpiling program. Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

1. Topsoil Stockpile Quantity Report: Provide a written report documenting the quantity, location and height of all stockpiled soil.

G. Required Soil Analysis Reports. Reports to be dated no more than [3] months prior to soil preparation.

1. Soil Analysis Plan: Contractor to submit annotated plan showing confirmed locations of all required soil tests. Each location is to be identified with a unique label.

2. Soil Analysis Report of Stockpiled Topsoil: Provide soil analysis report for each topsoil stockpile. Soils analysis report to be performed by Waypoint Analytical, a certified soil analysis laboratory, and include agricultural suitability analysis and recommendations for amending the soil. Subsoil will not be approved as planting soil.

3. Existing Planting Soil Analysis: After approval of the Soil Analysis Plan, rough grading, and topsoil placement, contractor to obtain [3] representative samples of in situ topsoil taken from approved site locations at depth of 4" to 6" below finish grade and submit to an accredited soils testing laboratory for "agricultural suitability" analysis, including particle size, infiltration rate, and evaluation of physical and chemical properties of soil and recommendations for adding amendments and fertilizers to the soil.

4. Subsoil Analysis: In addition to the above required soil samples, contractor to obtain one representative sample of any subgrade soil that is to receive a layer of imported planting soil over it. The laboratory report shall include the soil's infiltration rate, total
combined silt and clay content for determining the total allowable combined silt and clay content of the imported planting soil specified herein.

5. **Imported Planting Soil Analysis:** Contractor to submit an “agricultural suitability” analysis report from an accredited soils testing laboratory, including particle size, infiltration rate, and evaluation of physical and chemical properties of soil and recommendations for adding amendments and fertilizers to the soil. Soil to conform to requirements in Part 2.

6. **Amended Planting Soil Analysis:** Significant issues with soil quality will require soil to be retested in the locations identified on Soil Analysis Plan, prior to proceeding with plant installation, to ensure that the recommendations in the report have been followed and the final Planting Soil is agriculturally suitable as described in Part 2.

H. The Contractor is responsible to follow all local water ordinances and make available to the local agency the soil analysis report and verification of its implementation as required.

I. Delivery Receipts upon request by Owner, provide delivery receipts for quantities of soil & amendments delivered to the site.

J. Plant sample of each variety of plant. Samples to be delivered to the site 2 weeks prior to plant installation and stored and maintained separately from entire quantity of delivered plants. Contractor to maintain plants throughout maintenance period. Plants to be reviewed in a single site visit.

K. Representative photos of each plant species. Photos to be of plants to be delivered to site and not a stock photograph.

L. Entire plant quantity delivered to the site. Plants to be reviewed prior to installation during a single site visit.

M. Representative photos of each tree species (unless trees previously tagged at nursery by landscape architect). Photos to be of trees to be delivered to site and not a stock photograph.

1.5 **WARRANTY AND REPLACEMENT**

A. Maintenance Period: See Part 3.

B. Warrant the work against weed growth for a period of four (4) months after application of Pre-Emergence Weed Killer.

C. Warrant all plants to be in a healthy, thriving condition until the end of the maintenance period, and deciduous trees, shrubs and vines beyond that time until active growth is evident.

D. Replace all dead and damaged plants and plants not in a vigorous condition immediately upon discovery and as directed by the Owner’s Representative and at no cost to the owner. Install replacement plants before the final acceptance of the maintenance period in the size specified.

E. Warrant all products, prepared soils and plant material installed and maintained by contractor against defects for a period of one year after final acceptance of the maintenance period.
PART 2 - PRODUCTS

2.1 SUBSOIL

A. **Submit soil analysis report** from an approved soils laboratory for approval by the Landscape Architect. Refer to Part 1 for soil testing requirements.

2.2 EXISTING PLANTING SOIL (ON-GRADE):

A. Existing Planting Soil is defined as on-site topsoil that has been removed and stockpiled for reuse. Satisfactory planting soil shall be free of subsoil, clay, lumps, stones, and other objects over 4" in diameter, and without weeds, roots, and other objectionable material. The soil shall be fertile, friable, natural, productive soil containing a normal amount of humus, and shall be capable of sustaining healthy plant life. Soil shall not be infested with nematodes or with other noxious animal life or toxic substances. Soil shall be obtained from well-drained, arable land, and shall be of an even texture. Soil shall not be taken from areas on which are growing any noxious weeds such as Morning Glory, Equisetum, or Bermuda Grass, etc.

B. If herbicide contamination is suspected then a radish/ryegrass growth trial must be performed. Consult with Landscape Architect prior to decision to test or not.

C. Amended Planting Soils are to conform with the following target levels. Elements are expressed as mg/kg dry soil or mg/l for saturation extract

<table>
<thead>
<tr>
<th>pH value</th>
<th>6.5-7.9,</th>
<th>iron</th>
<th>4-15 mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>lime</td>
<td>none present</td>
<td>manganese</td>
<td>0.6-3.0 mg/kg</td>
</tr>
<tr>
<td>salinity (ECe)</td>
<td>0.5-3 milli-mho/cm</td>
<td>zinc</td>
<td>1-3 mg/kg</td>
</tr>
<tr>
<td>chloride</td>
<td>&lt;150 ppm</td>
<td>copper</td>
<td>0.2-3.0 mg/kg</td>
</tr>
<tr>
<td>nitrate</td>
<td>20-30 ppm</td>
<td>boron</td>
<td>0.2-0.5 mg/kg</td>
</tr>
<tr>
<td>SAR</td>
<td>&lt;3</td>
<td>magnesium</td>
<td>25-100 mg/kg</td>
</tr>
<tr>
<td>phosphorus</td>
<td>8-20 mg/kg</td>
<td>sodium</td>
<td>&lt;200 mg/kg</td>
</tr>
<tr>
<td>potassium</td>
<td>60-180 mg/kg</td>
<td>sulfur</td>
<td>25-100 mg/kg</td>
</tr>
</tbody>
</table>

D. If sufficient on-site surface topsoil is not available, contractor to provide imported planting soil as specified below. Placement of dissimilar soils shall be coordinated with irrigation zones by the contractor to maintain separate valves for dissimilar soils.

E. **Submit soil analysis report** from an approved soils laboratory for approval by the Landscape Architect. Refer to Part 1 for soil testing requirements.

2.3 IMPORTED PLANTING SOIL (ON-GRADE):

A. Imported planting soil shall be screened and shall be free of subsoil, heavy or stiff clay, rocks, gravel, brush, roots, weeds, noxious seeds, sticks, trash, and other deleterious substances.

B. Imported Planting Soils are to conform with the following target levels. Elements are expressed as mg/kg dry soil or mg/l for saturation extract
### pH value

- 6.5-7.9

### lime

- none present

### salinity (ECe)

- 0.5-3 milli-mho/cm

### chloride

- <150 ppm

### nitrate

- 20-30 ppm

### SAR

- <3

### phosphorus

- 8-20 mg/kg

### potassium

- 60-180 mg/kg

### iron

- 4-15 mg/kg

### manganese

- 0.6-3.0 mg/kg

### zinc

- 1-3 mg/kg

### copper

- 0.2-3.0 mg/kg

### boron

- 0.2-0.5 mg/kg

### magnesium

- 25-100 mg/kg

### sodium

- <200 mg/kg

### sulfur

- 25-100 mg/kg

---

C. The silt and clay content of Imported Planting Soil shall not exceed that of the existing soil it is to be placed over. Except where otherwise required, it shall be a "Sandy Loam" as classified in accordance with USDA Standards with a combined total of between 25% to 40% Clay and Silt.

D. **Submit soil analysis report** from an approved soils laboratory for approval by the Landscape Architect. Refer to Part 1 for soil testing requirements.

E. Following approval of the sample, provide a one-half cubic yard sample, which shall be stored at the site for comparison with sample and subsequent loads of soil. The comparison sample shall be protected by a cover until the installation of all soil has been completed and accepted.

---

### 2.4 PLANTING SOIL FOR STORMWATER TREATMENT

A. Planting soil for stormwater treatment shall be used in landscape areas designed for infiltration and the filtration of stormwater runoff before entering the storm drain system as specified below and as shown in drawings.

B. Planting soil mixes for stormwater treatment are available from TMT Enterprises in San Jose, CA, (408-432-9040); American Soil and Stone in Richmond, CA (510-292-3000) and San Rafael, CA (415-456-1381); and Lyngso Garden Materials in Redwood City, CA, (650-364-1730); or approved equal.

C. Planting soil for stormwater treatment shall conform to the following:

1. All material shall be free of trash and debris, expansive clays or any other deleterious materials.
2. Material shall be free of seeds.
3. The mineral component shall be classified as USDA sand or loamy sand and shall conform to the following particle size and characteristics.

<table>
<thead>
<tr>
<th>US Sieve</th>
<th>Size (mm)</th>
<th>Class</th>
<th>% wt. retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>#10</td>
<td>2.0</td>
<td>Gravel</td>
<td>0-10</td>
</tr>
<tr>
<td>#35</td>
<td>2.0-0.5</td>
<td>coarse sand</td>
<td>20-35</td>
</tr>
<tr>
<td>#270</td>
<td>&lt;0.05</td>
<td>Silt &amp; Clay</td>
<td>6-12</td>
</tr>
</tbody>
</table>

Rock ½ inch – 1 inch = 0-5% by volume with none > 1 inch
Organic = 0-3% by weight

4. **Percolation Rate** must fall in the range of 10 inches per hour Initial Rate and 5 inches Sustained Rate as determined by SPL method A06-2, unless otherwise specified by civil engineer.
5. Chemistry Suitability Considerations
   Salinity: Saturation Extract Conductivity (ECe) Less than 3.0 dS/m @ 25° C.
   Sodium: Sodium Adsorption Ratio (SAR) Less than 6.0
   Boron: Saturation Extract Concentration Less than 1.0 ppm
   Reaction: pH of Saturated Paste: 5.5 – 7.8 without high lime content.

   Top 6” should be amended with the approved organic composted yard waste. See Part 3 for amendment procedures.

D. Submit Soil analysis report(s) for approval by the Landscape Architect and Civil Engineer. Refer to Part 1 for soil testing requirements.
   1. Submit soil analysis report (including infiltration rate) for planting soil mix for stormwater treatment from an approved soils laboratory.
   2. Submit subsoil analysis report (including infiltration rate) for subsoils if planting area is designed to allow stormwater to infiltrate into native subsoils.

2.5 ORGANIC AMENDMENT FOR PLANTING SOILS (ON-GRADE):

   A. Ground Redwood or Ground Fir Bark with the following properties:
      
      | Percent Passing | Sieve Designation |
      |-----------------|-------------------|
      | 100             | 9.51 mm 3/8"      |
      | 50-60           | 6.35 mm 1/4"      |
      | 20-40           | 4.76 mm No. 4     |
      | 0-20            | 2.38 mm No. 8 8 mesh |

      Redwood Sawdust
      Dry bulk density, lbs. per cu. yd., 260-280
      Nitrogen stabilized - dry weight basis, min. 0.4%
      Salinity (ECe): 4.0 maximum
      Organic Content: 90% minimum
      Reaction (pH): 4.0 minimum

      Ground Fir and/or Pine Bark
      Dry bulk density, lbs. per cu. yd., Min. 350
      Nitrogen stabilized - dry weight basis, min. 0.5%
      Salinity (ECe): 4.0 maximum
      Organic Content: 90% minimum
      Reaction (pH): 4.0 minimum

   B. Submit sample, product’s technical data sheet, and analysis report from an approved soils laboratory for approval by the Landscape Architect. The analysis report should include compliance to the specifications above and directions for product use.

   C. Contractor may use Composted Yard Waste Amendment in lieu of the above specified Organic Amendment pending approval of product’ technical data sheet.

2.6 COMPOSTED YARD WASTE AMENDMENT FOR PLANTING SOILS (ON-GRADE):
   Courtesy of Soil & Plant Laboratory, Inc. Santa Clara, CA

   A. The above ORGANIC AMENDMENT FOR PLANTING SOILS (ON-GRADE) is the specified organic amendment material. Acceptance of Composted Yard Waste Amendment in lieu of the above specified amendment material will be considered if the in situ planting soil salinity and soil structure is favorable for the inclusion of recycled yard waste organic matter, as approved by the Landscape Architect.
B. Composted yard waste amendment will not be accepted for use in on-structure raised planters and pots.

C. The composted yard waste amendment shall be a mixture of feedstock materials including green material consisting of chipped, shredded, or ground vegetation and mixed food waste, or clean processed recycled wood products. Single source, biosolids (sewage waste) compost will not be acceptable.

D. The addition of the compost shall result in a final ECe of the amended soil of less than 4.0 dS/m @ 25 degrees C. as determined in a saturation extract. Use the following table to determine the maximum allowable Ece (dS/m of saturation extract) of compost at desired use rate and allowable Ece increase.

<table>
<thead>
<tr>
<th>DESIRED USE RATE</th>
<th>MAXIMUM ALLOWABLE Ece INCREASE FROM AMENDMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu. Yds. Amendment Per 1000 Sq. Ft. for Incorporation to 6&quot; depth</td>
<td>Volume percentage of amendment</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
</tr>
<tr>
<td>5</td>
<td>27</td>
</tr>
<tr>
<td>6</td>
<td>32</td>
</tr>
</tbody>
</table>

Example: Specification calls for 6 cu. Yrds. Compost per 1000 sq. ft. for incorporation to 6" depth, and site soil has an ECe of 2.0. In order to avoid exceeding ECe of 4 in final blend, compost ECe shall be less than 4.5 dS/m.

E. Composted Yard Waste Soil Amendment properties to conform to the following:

1. Gradation:
   - % Passing by weight
   - Sieve Designation
   - 90 1/2"
   - 85-100 9.51 mm 3/8"
   - 50-80 2.38 mm No. 8
   - 0-40 500 micron No. 35

2. Organic Content: Minimum 50% based on dry weight and determined by ash method. Minimum 250 lbs. organic matter per cubic yard of compost.

3. Carbon to nitrogen ratio: Maximum 35:1 if material is claimed to be nitrogen stabilized.

4. pH: 5.5 – 8.0 as determined in saturated paste.

5. Soluble Salts: See B. above.

6. Moisture Content: 35-60%.

7. Contaminants: The compost shall be free of contaminants such as glass, metal and visible plastic. Heavy meals, fecal coliform and Salmonella shall not exceed levels outlined as acceptable in the California integrated waste management regulations.

8. Maturity: Physical characteristics suggestive of maturity include:
   - Color: Dark brown to black.
   - Acceptable Odor: None, soil-like, or musty.
   - Unacceptable Odor: Sour, ammonia or putrid.
d. Particle Characterization: Identifiable wood pieces are acceptable but the balance of the material shall be soil-like without recognizable grass or leaves.

F. **Submit sample, product’s technical data sheet, and analysis report** from an approved soils laboratory for approval by the Landscape Architect. The analysis report should include compliance to the specifications above, directions for product use, and a list of ingredients. It is the Contractor’s responsibility to secure test of the proposed composted yard waste amendment (2 quart sample) and submit to a Soils Laboratory for evaluation and recommendations. The composted yard waste amendment sample shall be a grab sample from the currently available material that has been tested within the last 30 days and shall include the composter’s Compost Technical Data Sheet that includes lab analytical test results and directions for product use along with list of ingredients. Refer to Part 1 for soil testing requirements.

G. Based on the Soils Laboratory evaluation, the addition of composted yard waste amendment shall not be acceptable if it creates a leaching requirement.

2.7 PLANTS

A. Plant the variety, quantity and size indicated on drawings. The total quantities indicated on the drawings are considered approximate and furnished for convenience only. Contractor shall perform plant quantity calculations and provide all plants shown on the drawings.

B. Measure trees and shrubs with branches in normal position. Height and spread dimensions indicated refer to the main body of the plant, and not from branch tip to tip.

C. Take precautions to ensure that the plants will arrive at the site in proper condition for successful growth. Protect plants in transit from windburn and sunburn. Protect and maintain plants on site by proper storage and watering.

D. Install healthy, shapely and well rooted plants with no evidence of having been root-bound, restricted or deformed.

E. Tag plants of the type or name indicated and in accordance with the standard practice recommended by the American Association of Nurserymen.

F. Substitutions will not be permitted, except as follows:

1. If proof is submitted to the Landscape Architect that any plant specified is not obtainable, a proposal will be considered for use of nearest equivalent size or variety with an equitable adjustment of contract price.

2. Substantiate and submit proof of plant availability in writing to the Landscape Architect within 10 days after the effective date of Notice to Proceed.

G. Tree Form:

1. Trees shall have a symmetrical form as typical for the species/cultivar and growth form.

2. Central Leader for Single Trunk Trees: Trees shall have a single, relatively straight central leader and tapered trunk, free of co-dominant stems and vigorous, upright branches that compete with the central leader. Preferably, the central leader should not have been headed; however, in cases where the original leader has been remove, an upright branch at least $\frac{1}{2}$ the diameter of the original leader just below the pruning point shall be present.
3. Potential Main Branches: Braches shall be evenly distributed radially around and appropriately spaced vertically along the trunk, forming a generally symmetrical crown typical for the species.

4. Headed temporary branches should be distributed around and along the trunk as noted above and shall be no greater than 3/8” diameter, and no greater than ½ diameter of the trunk at point of attachment.

H. Tree Trunk

1. Trunk diameter and taper shall be sufficient so that the tree will remain vertical without the support of a nursery stake.

2. Trunk shall be free of wounds (except properly-made pruning cuts), sunburned areas, conks (fungal fruiting-bodies), wood cracks, bleeding areas, signs of boring insects, galls, cankers and/or lesions.

3. Tree trunk diameter at 6” above the soil surface shall be within the diameter range shown for each container size below, except where shown otherwise:

<table>
<thead>
<tr>
<th>Container</th>
<th>Trunk Diameter</th>
<th>Soil level from Container Top</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 gallon</td>
<td>0.5” to 0.75”</td>
<td>1.25 to 2”</td>
</tr>
<tr>
<td>15 gallon</td>
<td>0.75” to 1.0”</td>
<td>1.75 to 2.75”</td>
</tr>
<tr>
<td>24” Box</td>
<td>1.5” to 2.5”</td>
<td>2.25 to 3”</td>
</tr>
<tr>
<td>36” Box</td>
<td>&gt;2.5”</td>
<td>2.25 to 3”</td>
</tr>
<tr>
<td>60” Box</td>
<td>&gt;2.5”</td>
<td>3-6”</td>
</tr>
</tbody>
</table>

4. Tree trunks shall be undamaged and uncut with all old abrasions and cuts completely callused over. Do not prune plants prior to delivery.

I. Tree Roots

1. Trunk root collar (root crown) and large roots shall be free of circling and/or kinked roots. Contractor may be required to remove soil near the root collar in order to verify that circling and/or kinked roots are not present.

2. The tree shall be well rooted in the container. When the trunk is lifted the trunk and root system shall move as one and the rootball shall remain intact.

3. The top-most roots or root collar shall be within 1” above or below the soil surface. The soil level in the container shall be within the limits shown in above table.

4. The rootball periphery shall be free of large circling and bottom-matted roots.

5. On grafted or budded trees, there shall be no suckers from the root stock.

2.8 FERTILIZERS

A. General Landscape Fertilizers

Commercial fertilizer, pelleted or granular form, conform to the requirements of Chapter 7, Article 2, of the Agricultural Code of the State of California for fertilizing materials as follows:

**Type A:**
6% Nitrogen, 20% Phosphorus Acid and 20% Potash, (6-20-20)

**Type B:**
21 gram planting tablets 20% Nitrogen, 10% Phosphoric Acid and 5% Potash (20-10-5) available from Agriform or 10gm BestPacks packets 20% Nitrogen, 10% Phosphoric Acid and 5% Potash (20-10-5) available from Best Fertilizer Co.

**Type C (Maintenance Fertilizer)**
Complete fertilizer 21% Nitrogen, 7% Phosphoric Acid and 14% Potash (21-7-14).
If commercial fertilizer having the above analysis is not obtainable, other similar commercial fertilizer may be used providing it meets the approval of the Landscape Architect.

B. **Hydroseed Fertilizer**

Hydroseed fertilizer to be used in the slurry shall be commercial fertilizers conforming to the requirements of the California Food and Agricultural Code, shall have a guaranteed analysis for nitrogen, phosphorus and potassium of 7-2-1. Products specified as slow release shall have been tested and demonstrate a nearly linear curve.

2.9 **IRON SULFATE:** Dry form.

2.10 **EROSION CONTROL NETTING**

A. New, with a uniform, open plain-weave, flame-retardant mesh. The mesh shall be [natural brown-tan] and made from unbleached single jute yarn. The yarn shall be of loosely twisted construction and shall not vary in thickness by more than one-half its normal diameter. Furnish jute mesh in rolled strips to meet the following requirements:

- **Width:** 48 inches, with a tolerance of one-inch wider or narrower.
- **Not less than 78 warp ends per width.**
- **Not less than 41 weft ends per yard.**

2.11 **PERFORATED DRAIN PIPE**

A. Polyvinyl Chloride (PVC) pipe and pipe fittings shall meet extra strength minimum of SDR-35 of the requirements of ASTM Specification D3034.

B. Perforated and non-perforated corrugated polyethylene pipe, 3- to 10-inch diameter, shall meet the requirements of ASTM D883 and ASTM F412, and shall conform to Section 68 of the Standard Specifications.

C. Corrugated polyethylene pipe fittings shall comply with all requirements of AASHTO M-252-85I for 3- to 10-inch diameter pipe. Couplings shall be split or snap-on type for perforated pipe and split couplings with gaskets for non-perforated pipe. Cutting pipe with integral couplings will not be allowed.

D. Corrugated polyethylene pipe and fittings manufactured by Advanced Drainage Systems, Inc., shall be considered the standard to determine compliance to this specification.

E. Inspection Tube Cap: Paint cap one coat chocolate-brown color using Flat, exterior grade latex paint as accepted by Owner's Representative.

2.12 **FILTER FABRIC / PERMEABLE LANDSCAPE FABRIC**

A. Polyester or polypropylene non-woven filter fabric with uniform fiber distribution by "Terra Bond" #1115, "Mirafi, Inc." #140N, or approved equal.

2.13 **PERMEABLE DRAIN ROCK**

A. Permeable drain rock used in subsurface drain installations to be Class 2 permeable material in conformance with Section 68 "Subsurface Drains" of the Standard Specifications; gradation to 3/4" maximum size. Submit Sample for approval.
2.14 PRE-EMERGENCE WEED KILLER
   A. Clean non-staining as recommended by a licensed pest control specialist.

2.15 TREE STAKES
   A. Lodge pole pine logs, clean, smooth, un-treated.
   B. Unless otherwise shown on drawings, provide two-inch (2") diameter by eight feet (8') long for trees less than 8' high and 1" caliper.
   C. Unless otherwise shown on drawings, provide three-inch (3") diameter by eight to ten feet (8' - 10') long for trees greater than 8' high and 1" caliper.

2.16 TREE TIES
   A. Unless otherwise shown on drawings, provide rubber strap, 24-inch minimum length without sharp edges adjacent to trunk, V.I.T. cinch-tie, Dublin, CA, (818)882-9530, or approved equal.
   B. Black corded rubber tree ties w/ clips by greensleeves.com
   C. Biodegradable VStrap webbing by Treestrap.

2.17 MULCH
   A. Organic Mulch:
      1. Small Fir Bark, Forest floor bark mulch by American Soil and Stone, or approved equal
   B. Rock Mulch:
      1. Hard, durable smooth, river washed stone, 3/4-inch to 1-inch diameter in brown color range, Lin Creek or equal.
   C. Submit samples of rock mulch for approval by Landscape Architect until acceptable to Owner, at no extra cost.

2.18 STONES
   A. Smooth 2"-8" tan river pebbles, Lin Creek or equal.
   B. Stones to be installed around Drainage Structures to prevent mulch from migrating into stormdrain, and where shown in drawings

PART 3 - EXECUTION

3.1 PLANT PROTECTION AND REPLACEMENT
   A. Inspect and protect all existing and new plants and trees against damage from construction activities, erosion, trespass, insects, rodents, deer, disease, etc. and provide proper safeguards, including trapping of rodent and applying protective sprays and fencing to
discourage deer browsing. Maintain and keep all temporary barriers erected to prevent trespass.

B. Repair all damaged planted areas. Replace plants and re-seed or re-sod turf immediately upon discovery of damage or loss.

3.2 SOIL STRIPPING & STOCKPILING,
A. Refer to Section 311000, SITE CLEARING (soil stripping)

3.3 LIME TREATED SOIL
A. If site work includes Lime Treatment of the subsoil, the Contractor shall remove full depth of treated soil beyond 12” from structure(s) and replace with approved planting soil.

B. Following removal of lime treated material, scarify subgrade to a minimum depth of 6 inches and test for drainage.

C. Test subgrade in all planting areas for drainage by flooding with minimum 4 inch depth of water puddle and verify complete absorption of standing water within two hours. If standing water is still present after two hours, provide perforated pipe and drain rock “French Drain” system in bottom of non-draining planters and connect to storm drainage system, as accepted by Owner’s Representative prior to backfilling with approved planting soil.

3.4 GENERAL PREPARATION OF PLANTING SOIL
A. Submit soil analysis report of amended soils from an approved soils laboratory for approval by the Landscape Architect. Refer to Part 1 for soil testing requirements.

B. All planting soils to be amended as specified in soil laboratory analysis report(s).

C. Provide a minimum of [12"] depth of amended planting soil in all planting areas, or more where shown or specified otherwise. Install soil in maximum [12"] lifts. Compact each lift prior to installing subsequent lifts.

D. Amended subsoil is not an acceptable planting soil.

E. Thoroughly wet down the planting areas to settle the soil and confirm irrigation coverage and operation. Allow soil to dry so as to be workable as described herein.

F. After the rototill work, float areas to a smooth, uniform grade as indicated on the drawings. Slope all planting areas to drain. Roll, scarify, rake and level as necessary to obtain true, even planting surfaces. Remove rocks, sticks and debris 1 inch and larger in size in turf areas and 2 inches or larger in shrub and ground cover areas. Secure approval of the grade by the Landscape Architect before any planting.

G. Prior to planting, soil shall be loose and friable to a minimum depth of [12"] with a relative maximum compaction of 85%. Rip and scarify any overly compacted and re- compacted planting areas (in two directions full depth of compacted soil) prior to planting.

H. Water settling, puddling, and jetting of soil and backfill materials as a compaction method is not acceptable.
I. Prior to planting, soil shall be moist, but not so moist that it sticks to a hand shovel. Do not work planting soil in a wet or muddy condition or dump or spread in areas where subgrade is not in proper condition.

J. Provide planting soil as a final lift in all planting areas within and adjacent to paved areas and other construction where native site soil has been covered by engineered fill and/or base rock. Unless otherwise shown or specified, finish grade in planting islands shall be crowned with a minimum 2% pitch to drain.

K. Finish Grade: Hold finish grade and/or mulch surface in planting areas 1/2-inch below adjacent pavement surfaces, tops of curbs, manholes, etc. The subgrade of the mulch in mulched planting areas shall be a minus 2 inches at a distance of 12 to 18 inch from the edge of pavement. Drag finish grade to a smooth, even surface. Grade to form all swales and berms. Pitch grade with uniform slope to catch basins, streets, curb, etc., to ensure uniform surface drainage. Areas requiring grading include adjacent transition areas that shall be uniformly sloped between finish elevations. Slope surface away from walls so water will not stand against walls or buildings. Control surface water to avoid damage to adjoining properties or to finished work on the site. Take required remedial measures to prevent erosion of freshly graded areas.

L. Planting operations shall be performed only during periods when beneficial results can be obtained. When excessive moisture or other unsatisfactory conditions prevail, the work shall be stopped until conditions are satisfactory.

3.5 PREPARATION OF IMPORTED PLANTING SOIL

A. Provide a minimum of [12"] depth of imported planting soil in all planting areas, or more where shown or specified otherwise. Install soil in maximum [12"] lifts. Compact each lift prior to installing subsequent lifts.

B. Uniformly distribute and spread Subsoil or select fill in planting areas to achieve rough grading and compact to a maximum of 85% relative compaction.

C. Except within tree driplines, rip all planting areas in two directions full depth to a minimum of [12"] into undisturbed native subsoil prior to backfilling. Scarification of any planting area which cannot be accomplished with a tractor shall be accomplished by an alternative method approved by the Owner’s Representative to the specified depth to ensure proper percolation/drainage.

D. Thoroughly water-settle subsoil to required subgrade prior to installing Top Soil.

E. Prior to placing planting soil secure the Owner’s Representatives acceptance of the planting areas subgrade condition. Test depth of loose soil with hand shovel in presence of Owner’s Representative in several locations as directed.

F. After acceptance of the planting areas subgrade condition, uniformly distribute and spread planting soil backfill over scarified subgrade in planting areas as specified.

G. Mix and amend soil with required fertilizers, nutrients, etc. per specifications herein and recommendations given in soils reports.
3.6 PREPARATION OF IN-SITU PLANTING SOIL

A. In-Situ Planting Soil is defined as topsoil left in its original place and undisturbed during construction activities which is to receive new planting.

B. Amended subsoil is not an acceptable planting soil.

C. Contractor to provide soil report for any in-situ planting soil proposed for reuse. If in-situ planting soil is determined to be an acceptable planting soil, contractor to provide credit to owner for reduced quantity of imported planting soil.

D. Except within tree driplines, rip all planting areas in two directions full depth to a minimum of [12"] into undisturbed native subsoil prior to amending. Scarification of any planting area which cannot be accomplished with a tractor shall be accomplished by an alternative method approved by the Owner's Representative to the specified depth to ensure proper percolation/drainage.

E. Inspect planting areas and remove all base rock and other foreign material. Verify placement of planting soil within dripline of trees with Owner's Representative.

A. Test depth of loose soil with hand shovel in presence of Owner’s Representative in several locations as directed.

B. After acceptance of the planting condition, uniformly mix and amend soil with required fertilizers, nutrients, etc. per specifications herein and recommendations given in soils reports.

C. In the case of a contradiction between the quantity of organic amendment required by the soils laboratory analysis and the specified quantity below, the greater of the two quantities shall take precedence. Spread organic amendment, iron and Type A fertilizer evenly over installed and rough graded on-site topsoil in all planting areas including turf, ground cover and shrub areas at the following rates:
   a. Organic Amendment: 6 cubic yards per 1,000 square feet
   b. Fertilizer: Type A (6-20-20) at 20 lbs. per 1,000 square feet.
   c. Iron Sulfate: 10 lbs. per 1,000 square feet

2. Rototill above additives into soil [8-12"] inches deep. Keep iron sulfate off pavement and other surfaces to prevent rust staining. Correct all rust damage to work.

D. Final planting soil shall have a pH range of 6.5 to 7.5.

3.7 SOIL PREPARATION FOR STORMWATER TREATMENT PLANTING AREAS

A. Earthwork, rough grading, and drainage materials shall be complete and approved prior to installation of planting soil.

B. Do any necessary finish grading in addition to that performed in accordance with earthwork to bring subgrades after final compaction to required grades and sections as indicated.

C. Install the approved specified soil mix for infiltration planting areas as shown in Drawings. Soil depth to be 18” minimum typical and 24” minimum for planting areas with trees, unless otherwise shown on drawings.

D. After placement of the mineral component, the top 6” should be blended with the approved compost for stormwater treatment planting areas. If bulk blended, proportions should be 1
part compost to 4 parts of the above mineral component. If blended in place, this is equivalent
to 4 ½ cubic yards or 1,000 square feet for blending to 6-inch depth

E. If organic content of the mineral component is less than 0.6% weight, then it should be blended
with compost in volume proportions of 5% compost to 95% mineral.

F. Finish Grade: Provide a smooth, even surface. Sideslopes of stormwater planting areas (eg.
bioswales, basins, etc) not to exceed 3:1 in any direction. Finish grade of flow through planters
to be as shown in drawings.

3.8 WEED GERMINATION

A. Work shall be done under the supervision of a person licensed by the State of California as a
pest control applicator and holding a qualified applicator license or a Qualified Applicator
Certificate.

B. Following soil preparation and fine grading of planting areas, irrigate the planting areas to
germinate any weed seeds for a minimum period of 21 days. Maintain the soil in a damp
condition for a minimum depth of 4 inches. Following approval of the weed germination by the
Owner’s Representative, spray kill the weeds using a short lived systemic weed killer that will
not affect subsequent planting. Confirm the weed kill and allow the soil to dry out to optimum
degree for planting prior to planting.

3.9 PRE-EMERGENCE WEED KILLER

A. Work shall be done under the supervision of a person licensed by the State of California as a
pest control applicator and holding a qualified applicator license or a Qualified Applicator
Certificate.

B. Apply pre-emergence weed killer in all areas to receive ground cover planting. Obtain
approval of the finish grades prior to applying weed killer and coordinate planting and watering
with the pest control specialist prior to planting. Take care to keep weed killer off areas to be
seeded.

3.10 EROSION CONTROL NETTING

A. Verify finished grades and provide Jute Mesh and single grind Redwood bark mulch on all
slopes 3:1 and steeper as accepted by the Owner’s Representative. Install jute mesh loosely
up and down the slope in accordance with manufacturer's specifications and as follows. Fit the
soil surface contour and hold in place with 12-inch long, 11-gauge (minimum) steel wire
staples driven vertically into the soil at 18- to 24-inch spacing. Jute mesh strips shall overlap
along all edges at least 6 inches. Ends of side strips shall be buried into the soil at least 6
inches. Drive staples along edges to securely anchor mesh to ground.

3.11 TREE AND SHRUB PLANTING

A. Mark tree and shrub locations on site using stakes, gypsum or similar approved means and
secure location approval by the Landscape Architect before plant holes are dug. Adjust
location as required prior to planting.

B. Review location of plants in relationship to irrigation heads and adjust location(s) that interfere
with the function of the spray heads. Adjust locations as required to ensure that the plant roots
receive the proper amount of water in order for the plants to thrive.
A. Square Tree Pits
   1. Drilled tree pits shall be modified to a square pattern with pit walls scarified to promote root penetration.

B. Excavate tree, shrub and vine pits as follows:

<table>
<thead>
<tr>
<th></th>
<th>Width</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boxed Trees</td>
<td>Box + 24&quot;</td>
<td>Box depth</td>
</tr>
<tr>
<td>Canned Trees (15 gc)</td>
<td>Can + 18&quot;</td>
<td>Can depth</td>
</tr>
<tr>
<td>Canned Shrubs/Vines (1-5 gc)</td>
<td>Can + 12&quot;</td>
<td>Can depth</td>
</tr>
</tbody>
</table>

C. Test drainage of plant beds and tree pits by filling with water (minimum 6"). The retention of water in planting beds and plant pits for more than two (2) hours shall be brought to the attention of the Landscape Architect. If rock, underground construction work, tree roots, poor drainage, or other obstructions are encountered in the excavation of plant pits, alternate locations may be selected by Landscape Architect.

D. Break and loosen the sides and bottom of tree pits to ensure root penetration and water test hole for drainage as required above.

E. Excavate plant hole or tree pit keeping excavated planting soil layer on the surface when backfilling around the plant. Carefully set plants as detailed without damaging the rootball. Superficially cut edge roots vertically on three sides. Remove bottom of plant boxes before planting. Remove sides of boxes after positioning the plant and partially backfilling.

F. Set plants in backfill with top of the rootball 1 inch above finished grade of adjacent soil. Backfill remainder of hole and soak thoroughly by jetting with a hose and pipe section. Water backfill until saturated the full depth of the hole.

G. Backfill plant holes with mix as specified, free from rocks, clods or lumpy material. Backfill native soil free of soil amendments under rootball and foot tamp to prevent settlement. Backfill remainder of the hole with soil mix and place plant tablets or packets (Type B fertilizer) 3 inches below finish grade and 1/2-inch from roots at the following rates:

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Tablets or Packet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 gallon can plant</td>
<td>1 tablet or packet</td>
</tr>
<tr>
<td>5 gallon can plant</td>
<td>3 tablets or packet</td>
</tr>
<tr>
<td>15 gallon can plant</td>
<td>6 tablets or packet</td>
</tr>
<tr>
<td>24-inch box plant</td>
<td>6 tablets or packet</td>
</tr>
<tr>
<td>36-inch box plant</td>
<td>8 tablets or packet</td>
</tr>
</tbody>
</table>

H. Except for acid loving plants (Azaleas, Rhododendrons, Ferns, Camellias, etc.), use a soil mix of 2 parts soil from the hole, and 1 part amendment with iron added at the following rates:

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Amendment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 gallon can plants</td>
<td>iron, 1/4 cup</td>
</tr>
<tr>
<td>5 gallon can plants</td>
<td>iron, 1/3 cup</td>
</tr>
<tr>
<td>15 gallon can plants</td>
<td>iron, 1/2 cup</td>
</tr>
<tr>
<td>24&quot; box and larger</td>
<td>iron, 1 cup</td>
</tr>
</tbody>
</table>

For acid loving plants (Azaleas, Rhododendrons, Ferns, Camellias, etc.), mix 1 part soil from the hole and 1 part amendment to use a backfill around the plants.

Mix the iron, amendment and soil thoroughly for use in the top 8 inches of backfill around plants. For acid loving plants, mixture to be 1/2 soil from the hole and 1/2 amendment.
I. Remove any soil from top of plant rootballs and secure Landscape Architect's approval of rootball height prior to mulching.

J. After approval of rootball height, install mulch as required below.

K. Stake and/or guy trees as detailed. Drive stake(s) until solid (at least 12" beyond bottom of rootball) and remove excess stake protruding above top tree tie to prevent rubbing against branches. Avoid driving stakes through rootball. If subgrade does not accept stakes to a stable degree, delete stakes and guy the trees as specified herein and as detailed. Locate tree ties to avoid contact with tree branches. Locate top tie at tree flex point.

L. Build watering basin berms around trees and shrubs to drain through rootball. Water backfill until saturated the full depth of the hole.

3.12 GROUND COVER PLANTING

A. Plant in neat, straight, parallel and staggered rows as indicated on plan. Plant first row one-half required ground cover spacing behind adjacent curbs, structures, or other plant bed limits. Plant ground cover to edge of water basins of adjacent trees and shrubs.

3.13 MULCH:

A. Except where rock mulch is required, mulch all tree, shrub and ground cover areas with organic mulch to a 3-inch depth, except mulch to 2-inch depth where planting with ground cover plants from flats.

B. Hold bark mulch away from base (trunk) of plant 4" or as directed by the Landscape Architect.

C. Individual trees and/or shrubs planted in non-irrigated areas shall, at minimum, receive bark mulch over their watering basin and berm.

D. Install rock mulch to depth as detailed, minimum 2-inches for full coverage of soil surface, whichever is greater.

3.14 WATERING:

A. Water all trees, shrubs and ground cover immediately after planting. Apply water to all plants as often and in sufficient amount as conditions may require to keep the plants in a healthy vigorous growing condition until completion of the Contract. Provide supplemental hand watering of trees and shrubs, as required, to maintain a moist root zones throughout plant establishment period.

3.15 PRE-MAINTENANCE PERIOD REVIEW AND APPROVAL OF PLANTING

A. Maintain plants from time of delivery to site until final acceptance of landscape installation.

B. Receive approval of the installed planting prior to commencement of planting establishment maintenance period. Notify the Landscape Architect or Owner’s Representative a minimum of seven (7) days prior to requested review. Before the review, complete the following:

1. Complete all construction work.
2. Present all planted areas neat and clean with all weeds removed and all plants installed and appearing healthy.
3. Plumb all trees and tree and shrub supports.
3.16 PLANTING ESTABLISHMENT MAINTENANCE:

A. General Requirements:

1. **Maintenance Period:** The planting establishment maintenance period required shall be **120 calendar days** after all planting and irrigation is complete and as approved by Owner’s representative. A longer period may be required if the plant material is not acceptably maintained during the maintenance period. The start of the maintenance period to be confirmed by Owner’s representative. Contractor to notify landscape architect of start and end dates of maintenance period. The maintenance period may be suspended at any time upon written notice to the Contractor that the landscaping is not being acceptably maintained, and the day count suspended until the landscape is brought up to acceptable standards as determined by the Owner Representative.

2. Planting establishment maintenance immediately follows, coincides with, and is continuous with the planting operations, and continues after all planting is complete and accepted; or longer where necessary to establish acceptable stands of thriving plants.

3. Protect all areas against damage, including erosion, trespass, insects, rodents, disease, etc. and provide proper safeguards. Maintain and keep all temporary barriers erected to prevent trespass.

4. Keep all walks and paved areas clean. Keep the site clear of debris resulting from construction or maintenance activities.

5. Repair all damaged planted areas, and replace plants and resod turf immediately upon discovery of damage or loss.

6. Check sprinkler systems at each watering; adjust coverage and clean heads immediately. Adjust timing of sprinkler controller to prevent flooding.

7. Maintain adequate moisture depth in soil to ensure vigorous growth. Check rootball of trees and shrubs independent of surrounding soils and hand water as required.

8. Keep contract areas free from weeds by cultivating, hoeing or hand pulling. Use of chemical weed killers will not relieve the Contractor of the responsibility of keeping areas free of weeds at all times.

B. Tree and Plant Maintenance:

1. Maintain during the entire establishment period by regular watering, cultivating, weeding, repair of stakes and ties, and spraying for insect pests. Prune when requested by the Landscape Architect.

2. Keep watering basins in good condition and weed-free at all times.

3. Replace all damaged, unhealthy or dead trees, shrubs, grasses, vines and ground covers with new stock immediately; size as indicated on the drawings.

C. Fertilizing:

1. Upon approval and after submitting fertilizer delivery tags, maintenance fertilization shall begin 30 days after planting is complete. Fertilize all ground cover areas by broad-casting Type C (21-7-14) fertilizer at the rate of 5 lbs. per 1,000 square feet evenly throughout. Reapply every forty-five (45) days until acceptable.

2. During the winter, for quick turf greening effect, calcium nitrate (15.5-0-0) may be applied at the rate of 6 lbs. per 1,000 square feet.

3. Early spring and fall substitute a complete fertilizer such as 15-15-15 applied at the rate of 6 lbs. per 1,000 square feet, to help insure continuing adequate phosphorus and potassium.
4. Apply ammonium sulfate fertilizer as necessary to maintain vigorous, green grass between fertilizations mentioned above.

5. Observe plant's color, and if a soil pH imbalance is suspected, take soil samples and obtain laboratory analysis for confirmation. Take necessary action recommended in laboratory analysis such as top dressing with soil sulfur, leaching soil, etc.

3.17 FINAL PLANTING REVIEW AND ACCEPTANCE

A. At the conclusion of the Maintenance Period, schedule a final review with the Owner, the Owner's maintenance person, and/or the Landscape Architect. On such date, all project improvements and all corrective work shall have been completed. If all project improvements and corrective work are not completed, continue the planting establishment maintenance period at no additional cost to the Owner until all work has been completed. This condition will be waived by the Owner under such circumstances wherein the Owner has granted an extension of time to permit the completion of a particular portion of the work beyond the time of completion set forth in the Agreement.

B. Submit written notice requesting review at least 10 days before the anticipated review.

C. Prior to review, weed and restore all planted areas, mow and edge turf, plumb trees and tree supports, clear the site of all debris and present in a neat, orderly manner.

END OF SECTION
SECTION 329451 – MODULAR SUSPENDED PAVEMENT SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Section Includes:
   1. Furnishing and installing Modular Suspended Pavement System, including, but not limited to: geotextile, geogrids, aggregates, sub base material, backfill, drainage system, root barrier, concrete retainers and installation of planting soil.

B. Related work specified elsewhere includes:
   1. Section 32 11 32 AGGREGATE BASE COURSE
   2. Section 32 84 00 IRRIGATION
   3. Section 32 90 00 PLANTING
   4. Section 32 94 56 PLANTING SOIL FOR MODULAR SUSPENDED PAVEMENT SYSTEM

1.2 DEFINITIONS

A. Aggregate Sub Base (below Cell frame): Aggregate material between the bottom of the Cell frame and the compacted subgrade below. Designed to distribute loads from the frame to the subgrade, including subgrade drainage as shown.

B. Aggregate Base Course (above Cell deck): Aggregate material between the paving and the top of the Cell deck designed to distribute loads across the top of the deck.

C. Backfill: The earth used to replace or the act of replacing earth in an excavation beside the Cell frames to the excavation extents.

D. Bridging Slab: Bridging slabs are to be used in locations where spacing larger than 3 inches (75 mm) is necessary between Cell frames.

E. Compost: Organic material subjected to composting processes

F. Finish Grade: Elevation of finished surface of planting soil or paving.

G. Geogrid: Net-shaped synthetic polymer-coated fibers that provide a stabilizing force within soil structure as the fill interlocks with the grid.

H. Geotextile: A geosynthetic fabric, applied to either the soil surface or between materials, providing filtration, separation, or stabilization properties.

I. Inspection Riser for Drainage: Vertical, perforated pipe installed at tree openings to allow access for visual inspection of water levels at base of Modular Suspended Pavement system.

J. Inspection Riser for Soil: Vertical pipe installed as shown to allow access for visual inspection of soils moisture within the Modular Suspended Pavement system. Inspection riser to occur in each tree cutout as accepted by Owner's Representative.

K. Irrigation: as required within the soil of the Modular Suspended Pavement system.

L. Planting Soil: as required by Specification, 32 91 13, PLANTING SOIL PREPARATION.

M. Root Barrier: Plastic root diversion device.
N. Root package (rootball): The earthen package containing the root system of the tree as shipped from the nursery.

O. Silva Cells (Modular Suspended Pavement System): Plastic structural cellular system with posts, beams and decks designed to be filled with planting soil for tree rooting and support of vehicle loaded pavements.

P. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill.

Q. Strongback: Modified Silva Cell frame designed to be attached to top of Silva Cells for stability while installing planting soil and backfill.

R. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

S. Zip Tie: A tensioning device or tool used to tie similar or different materials together with a specific degree of tension.

1.3 SUBMITTALS

A. Upon Thirty (30) days prior to start of installation of items in this section, the Contractor shall provide submittals required in this section to the Owner's Representative for review and approval.

1. Schedule of work and coordination with other trades
2. Installer qualifications, including name and work experience of field supervisor.

B. Product Data: For each type of product, submit manufacturer's product literature with technical data sufficient to demonstrate that the product meets these specifications, including but not limited to:

1. Modular Suspended Pavement System,
2. Anchoring Spikes,
3. Solid and perforated drain lines,
4. Inspection risers and caps,
5. Geogrid,
6. Geotextile,
7. Aggregate sub base,
8. Aggregate base course,
9. Backfill Materials,
10. Root barrier,
11. Manufacturer's product warranty.
12. For bulk materials, including soils and aggregates, include analysis as required by Specifications.

C. Testing of mock up results

1. Compaction testing log

D. Modular Suspended Pavement System manufacturer's letter of review and approval of the project, plans, details and specifications for compliance with product installation requirements.

E. Modular Suspended Pavement System Mock Up:

1. Prior to the installation, construct a mock up of the complete installation at the site. The installation of the mock up shall be in the presence of the Owner's Representative and the Modular Suspended Pavement System Representative.
2. The mock up shall be a minimum of 100 square feet in area and include the complete system installation with sub base compaction, drainage installation, base course aggregate and geotextile
as required, geogrids, backfill, planting soil with compaction, decks, top geotextile and all necessary accessories.

3. The mock up area may remain as part of the installed work at the end of the project provided that it remains in good condition and meets all the conditions of the specifications.

F. Compaction testing results: Submit results of all compaction testing required by the specifications including the bulk density test of the mock up and installed soil to the Owner's Representative for approval.

G. Qualification Data: Submit documentation of the qualifications of the Modular Suspended Pavement System installer sufficient to demonstrate that the installer meets the requirements of paragraph "Quality Assurance".

1.4 SEQUENCING AND SCHEDULING

A. General: Prior to the start of Work, prepare a detailed schedule of the work for coordination with other trades.

B. Schedule all utility installations prior to beginning work in this section.

C. Where possible, schedule the installation of Modular Suspended Pavement Systems after the area is no longer required for use by other trades and work. Protect installed Modular Suspended Pavement Systems from damage in the event that work must occur over, through, or adjacent to the completed Modular Suspended Pavement Systems.

1.5 QUALITY ASSURANCE

A. Reference Standards:

1. Ordinances and Regulations: All local, municipal and state laws, codes and regulations governing or relating to all portions of this work are hereby incorporated into and made a part of these Specifications. Anything contained in these Specifications shall not be construed to conflict with any of the above codes, regulations or requirements of the same. However, when these Specifications and Drawings call for or describe materials, workmanship or construction of a better quality, higher standard than is required by the above mentioned codes and regulations, the provisions of these Specifications and Drawings shall take precedence. Furnish without extra charge additional materials and labor required to comply with above rules and regulations.

B. Coordination:

1. A minimum of two weeks prior to beginning construction of the Modular Suspended Pavement System Mock Up, notify and coordinate with the Owner and the Modular Suspended Pavement System Manufacturer, observation of the excavation, subgrade preparation, installation of the cell frame, backfilling, etc.

C. Installer Qualifications: Modular Suspended Pavement Systems and related products shall be installed by a qualified installer whose work has resulted in successful installation of planting soils and planter drainage systems, underground piping, chambers and vault structures.

1. Submit list of completed projects of similar scope and scale to the Owner's Representative, demonstrating capabilities and experience.

2. The installer and the field supervisor shall have a minimum of five years successful experience with construction of similar scope in dense urban areas.

3. Installer's Field Supervision: Installer is required to maintain an experienced full-time supervisor on Project site when work is in progress. This person shall be identified during the Pre-installation Conference, with appropriate contact information provided, as necessary. The same supervisor shall be utilized throughout the Project, unless a substitution is submitted to and approved in writing by the Owner's Representative.
1.6 LAYOUT AND ELEVATION CONTROL
   A. Provide layout and elevation control during installation of Modular Suspended Pavement Systems. Utilize grade stakes, benchmarks, surveying equipment and other means and methods to assure that layout and elevations conform to the layout and elevations indicated on the plans.

1.7 PERMITS AND CODE COMPLIANCE
   A. Comply with applicable requirements of the laws, codes, ordinances and regulations of Federal, State and Municipal authorities having jurisdiction. Obtain necessary permits/approvals from all such authorities.

1.8 DELIVERY, STORAGE, AND HANDLING
   A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, if applicable. Protect materials from deterioration during delivery and while on the project site.
   B. Bulk Materials:
      1. Do not deliver or place backfill, soils and soil amendments in frozen, wet, or muddy conditions.
      2. Provide protection including tarps, plastic and or matting between all bulk materials and any finished surfaces sufficient to protect the finish material.
   C. Provide erosion-control measures to prevent erosion or displacement of bulk materials and discharge of soil-bearing water runoff or airborne dust to adjacent properties, water conveyance systems, and walkways. Provide additional sediment control to retain excavated material, backfill, soil amendments and planting mix within the project limits as needed.
   D. Modular Suspended Pavement Systems: Protect Modular Suspended Pavement Systems from damage during delivery, storage and handling.
      1. Store under tarp to protect from sunlight when time from delivery to installation exceeds one week. Storage should occur on smooth surfaces, free from dirt, mud and debris
      2. Handling is to be performed with equipment appropriate to the size (height) of Cells and site conditions, and may include, hand, handcart, forklifts, extension lifts, or small cranes, with care given to minimize damage to Modular Suspended Pavement System frames, decks and adjacent Modular Suspended Pavement Systems.

1.9 PROJECT CONDITIONS
   A. Verification of Existing Conditions and Protection of New or Existing Improvements: Before proceeding with work in this section, the Installer shall carefully check and verify all dimensions, quantities, and grade elevations, and inform the Owner's Representative immediately of any discrepancies.
      1. Carefully examine the civil, record, and survey drawings to become familiar with the existing underground conditions before digging. Verify the location of all aboveground and underground utility lines, infrastructure, other improvements, and existing trees, shrubs, and plants to remain including their root system, and take proper precautions as necessary to avoid damage to such improvements and plants.
      2. In the event of conflict between existing and new improvements notify the Owner's Representative in writing and obtain written confirmation of any changes to the work prior to proceeding.
      3. When new or previously existing utility lines are encountered during the course of excavation, notify the Owner's Representative in writing and make recommendations as to remedial action. Proceed with work in that area only upon approval of appropriate remedial action. Coordinate all work with the appropriate utility contractors, utility company or responsible public works agency.
B. Weather Limitations: Do not proceed with work when subgrades, soils and planting soils are in a wet, muddy or frozen condition.

C. Protect partially completed Modular Suspended Pavement System installation against damage from other construction traffic with highly visible construction tape, fencing, or other means until construction is complete. Prevent all non-installation related construction traffic over the completed Modular Suspended Pavement System installation; allowing only loads less than the design loads.

1.10 PROTECTION

A. Protect open excavations and partially completed Modular Suspended Pavement System installation from access and damage when work is in progress, and following completion with highly visible construction tape, fencing, or other means until all construction is complete.

1.11 WARRANTY

A. Modular Suspended Pavement System manufacturer's product warranty shall apply. Submit manufacturer's product warranty.

1.12 PROJECT WORK

A. Coordinate installation with all other work that may impact the completion of the work.

1.13 PRECONSTRUCTION MEETING

A. Prior to the start of the installation of Modular Suspended Pavement Systems, meet at the site with the Owner's Representative, general contractor and the Modular Suspended Pavement Systems installer to review installation layout, procedures, means and methods.

PART 2 - PRODUCTS

2.1 MODULAR SUSPENDED PAVEMENT SYSTEMS


B. Fiberglass-reinforced polypropylene structures including frames and decks designed to support sidewalk loads and designed to be filled with soil for the purpose of growing tree roots, and rainwater filtering, detention and retention.

C. Silva Cell Frames: 400 mm x 600 mm x 1200 mm (16 inches x 24 inches x 48 inches).

D. Silva Cell Deck: 5 cm x 600 mm x 1200 mm (2 inches x 24 inches x 48 inches). Deck to include manufactured installed galvanized steel tubes.

E. Silva Cell Strongback: 400 mm x 600 mm x 150 mm (24 inches x 48 inches x 6 inches) modified Modular Suspended Pavement System Frame units designed to stiffen and align the frames as planting soil and backfill material is placed. Strongbacks are to be removed prior to placing decks. They are to be reused as the work progresses.

F. Silva Cell Deck Screws: Manufacturer's supplied stainless steel screws to attach decks to frames.

2.2 ANCHORING SPIKES

A. 10" (250 mm) long X 19/64" (8 mm) diameter, spiral, galvanized timber spikes. Utilize 4 spikes in each frame on the first layer of Silva Cells to anchor the frames to the aggregate sub base.
2.3 SOLID AND PERFORATED DRAIN LINES
   A. Any solid or perforated drain lines to be specified...

2.4 INSPECTION RISER FOR DRAINAGE (where applicable):
   A. Rigid, PVC schedule 40 pipe, 4” diameter.
   B. Cap: Cast Iron solid threaded cleanout designed to fit standard PVC schedule 40 pipe-fittings with concrete collar set flush in pavement surface as accepted by Owner's Representative.
      1. Products meeting this specification: Zurn Z 1440, Cast Iron Adjustable Cleanout, Zurn, 1801 Pittsburgh Avenue, Erie, PA 16502, 1-877-ZURN-NOW. http://www.zurn.com/

2.5 INSPECTION RISER FOR SOIL (where applicable):
   A. Rigid, PVC schedule 40 pipe, 6” diameter.
   B. Cap: Cast Iron solid threaded cleanout designed to fit standard PVC schedule 40 pipe-fittings.
      1. Products meeting this specification: Zurn Z 1440, Cast Iron Adjustable Cleanout, Zurn, 1801 Pittsburgh Avenue, Erie, PA 16502, 1-877-ZURN-NOW. http://www.zurn.com/

2.6 INSPECTION RISER FOR SOIL LOCATED IN TREE WELL
   A. Rigid, Perforated PVC schedule 40 pipe, 4” diameter.
   B. Cap: PVC solid threaded cleanout designed to fit standard PVC schedule 40 pipe-fittings. Cap painted color to match Granite Pavers as accepted by Owner’s Representative.

2.7 GEOGRID
   A. Geogrid shall be woven polyester fabric with PVC coating, Uni-axial or biaxial geogrid, inert to biological degradation, resistant to naturally occurring chemicals, alkalis, acids.
      1. Tensile strength at ultimate: 1850 lbs/ft (27.0 kN/m) minimum by ASTM D6637 test method
      2. Creep reduced strength: 1000 lbs/ft (14.6 kN/m) minimum by ASTM D5262 test method
      3. Long term allowable design load: 950 lbs/ft (13.9 kN/m) minimum by GRI GG-4 test method
      4. Grid aperture size (MD): 0.8 inch (20 mm) minimum
      5. Grid aperture size (CD): 1.28 inch (32 mm) maximum
      6. Roll size: 6’ (1.8m) width is preferred, up to 18’ (5.4m)
   B. Products meeting this specification:

2.8 GEOTEXTILE
   A. Geotextile shall be nonwoven polypropylene fibers, inert to biological degradation and resistant of naturally occurring chemicals, alkalis and acids.
      1. Grab tensile strength: 200 lbs (900 N) minimum (ASTM D 4632 test method)
      2. Elongation: 50% maximum (ASTM D 4632 test method)
      3. Trapezoid tear strength: 80 lbs (350 N) minimum (ASTM D 4533 test method)
      4. Mullen burst strength: 350 psi (2400 kPa) minimum (ASTM D 3786 test method)
      5. Puncture strength: 110 lbs (490 N) minimum (ASTM D 4833 test method)
6. CBR puncture strength: 500 lbs (2225 N) minimum (ASTM D 6241 test method)
7. Apparent opening size: 80 sieve (0.18mm) maximum (ASTM D 4751 test method)
8. Flow rate: 95 gal/min/ft² (3870 l/min/m²) minimum (ASTM D 4491 test method)
9. UV Resistance (at 500 hours): 70% strength retained

B. Products meeting this specification:
      (Distributed by Geosynthetic Systems in Ontario)
   2. Geotex 801 as manufactured by Propex Geosynthetics, Chattanooga, TN,
      http://www.geotextile.com (Distributed by Nilex in Canada)

2.9  AGGREGATE SUB BASE (Drain Rock) BELOW CELL FRAME
   A. Aggregate subbase below Modular Suspended Pavement System frame to provide Modular
      Suspended Pavement System support and subsurface drainage: 3/4" X 1/4" clean, hard, durable
      virgin crushed rock meeting Caltrans Section 68 Submit Sample along with material analysis for
      approval.

2.10  CONCRETE BASE COURSE FOR NON-POROUS PAVEMENT (ABOVE CELL DECK)
   A. Refer to project's SECTION 3214 40, SAND & MORTAR-SET PAVING

2.11  SETTING BED FOR UNIT PAVERS (ABOVE CELL DECK)
   A. Refer to project SECTION 3214 40, SAND & MORTAR-SET PAVING Specifications for setting bed
      material requirements.

2.12  BACKFILL MATERIAL (ADJACENT TO MODULAR SUSPENDED PAVEMENT SYSTEMS):
   A. Clean, compactable, coarse grained fill soil meeting the requirements of the Unified Soil Classification
      system for soil type GW, GP, GC with less than 30% fines, SW, and SC with less than 30% fines.
      Backfill material shall be free of organic material, trash and other debris, and shall be free of toxic
      material injurious to plant growth.
   B. Submit supplier certificate for material meeting this specification.

2.13  PLANTING SOIL: (See Specification Section 32 91 13 PLANTING SOIL PREPARATION for Modular
      Suspended Pavement Systems)

2.14  ROOT BARRIER
   A. Root Barrier shall be DeepRoot; Tree Root Barriers; UB 18-2, manufactured by DeepRoot Partners,
      L.P. (Deep Root); 530 Washington Street, San Francisco, CA 94111; 415.781.9700; 800.458.7668; fax
   B. Material: Black, injection molded panels, 0.080"(2.03mm) wall thickness in modules 24" (61cm) long by
      18" (46cm) deep; manufactured with a minimum 50% post-consumer recycled polypropylene plastic
      with UV inhibitors; recyclable. Integrated zipper joining system providing for instant assembly by sliding
      one panel into another.

PART 3 - EXECUTION

3.1  LAYOUT APPROVAL
   A. Prior to the start of work, layout and stake the limits of excavation and horizontal and vertical control
      points sufficient to install the Modular Suspended Pavement Systems and required drainage features in
      the correct locations.
### 3.2 EXCAVATION

A. Excavate to the depths and shapes indicated on the drawings. The base of excavation shall be smooth soil, level, and free of lumps or debris.

B. Do not over-excavate existing soil beside or under the limits of excavation required for the installation. If soil is over-excavated, install compactable fill material in lifts not more than 8 inches (200 mm) deep and compact to the required density.

C. Confirm that the depth of the excavation is accurate to accommodate the depths and thickness of materials required throughout the extent of the excavation.

D. Confirm that the width and length of the excavation is a minimum of 6 inches (150 mm), in all directions, beyond the edges of the Modular Suspended Pavement Systems.

### 3.3 SUBGRADE COMPACTION

A. Check compaction of the subgrade below the Modular Suspended Pavement Systems and confirm that the subgrade soil is compacted to a minimum of 95% of maximum dry density at optimum moisture content in accordance with ASTM D 698 Standard Proctor Method.

B. Proof compact the subgrade with a minimum of three passes of a suitable vibrating compacting machine or apply other compaction forces as needed to achieve the required subgrade compaction rate.

C. Apply additional compaction forces at optimum water levels.

### 3.4 INSTALLATION OF GEOTEXTILE OVER SUBGRADE

A. Where indicated on drawings, install geotextile over compacted subgrade.

B. Removal of the geotextile as a standard component of the Modular Suspended Pavement System system must be determined by professional civil or geotechnical engineer.

C. Install the geotextile with a minimum joint overlap of 18 inches (450 mm) between sections of material. Ensure geotextile is laid flat with no folds or creases.

### 3.5 INSTALLATION OF INSPECTION RISERS FOR DRAINAGE

A. Cut PVC pipe to fit vertically to finish surface.

B. Manually perforate riser. Pipe should be rigid at level of pavement section, and perforated through level of Modular Suspended Pavement System system.

C. Wrap pipe in geotextile and secure with zip ties. Brace riser for the remainder of installation to secure its location and elevation.

D. Install caps on top of each riser flush with grade. PVC caps shall be painted chocolate brown color using exterior grade paint.

### 3.6 INSTALLATION OF Aggregate SUB BASE BELOW MODULAR SUSPENDED PAVEMENT SYSTEM FRAME

A. Install aggregate sub base and subbase drainage system to the depths indicated on the drawings, under the first layer of Modular Suspended Pavement System frames. Sub base aggregate shall extend a minimum of 6 inches (150mm) beyond the edge of the Cell frames.

B. Compact aggregate sub base layer to a minimum of 95% of maximum dry density at optimum moisture content in accordance with ASTM D 698 Standard Proctor Method. Compact the subgrade with a
minimum of three passes of a suitable vibrating compacting machine or apply other compaction forces as needed to achieve the required subgrade compaction rate.

C. The maximum slope on the surface of the sub base shall be 5%. Where proposed grades on finished paving are greater than 5%, the Cells shall be stepped to maintain proper relationships to the finished grade.

D. The grade and elevations of the base under the Modular Suspended Pavement Systems shall be approved by the Owner's Representative prior to proceeding with the installation of the Modular Suspended Pavement Systems.

E. Note that the Modular Suspended Pavement System does not fully meet H-20 loading until the final paving is installed. No equipment shall be used on top of the Cell system until paving installation has been completed.

3.7 INSTALLATION OF MODULAR SUSPENDED PAVEMENT SYSTEMS, PLANTING SOIL, GEOGRID, AND BACKFILL

A. Identify the outline layout of the structure and the edges of paving around tree planting areas on the floor of the excavation, using spray paint or chalk line.

B. Lay out the first layer of Modular Suspended Pavement System frames on the sub base. Verify that the layout is consistent with the required locations and dimensions of paving edges to be constructed over the Modular Suspended Pavement Systems. Coordinate with drainage of sub base.

C. Check each Modular Suspended Pavement System frame unit for damage prior to placing in the excavation. Any cracked or chipped unit shall be rejected.

D. Place frames no less than 1 inch (25 mm) and no more than 3 inches (75 mm) apart at base. In the event that spacing between Cells exceeds 3 inches (75 mm), bridging slab details and methods shall be used to span these gaps.

E. Install Modular Suspended Pavement System frames around, over, or under existing or proposed utility lines as indicated on plans.

F. Where any two adjacent Modular Suspended Pavement System frames must be installed at different elevations, the upper frame shall be supported by aggregate sub base with a maximum slope of 1:1. This may require installation of aggregate sub base within the adjacent lower Cell frame. No two frames shall differ in elevation by more than 15 inches (375 mm).

G. Assure that each frame sits solidly on the surface of the sub base. Frames shall not rock or bend over any stone or other obstruction protruding above the surface of the sub base material. Frames shall not bend into dips in the sub base material. The maximum tolerance for deviations in the plane of the sub base material under the bottom of the horizontal beams of each Modular Suspended Pavement System frame shall be 1/4 inch (6 mm) in 4 feet (1200 mm).

H. Adjust sub base material including larger pieces of aggregate under each frame to provide a solid base of support.

1. Anchor each Modular Suspended Pavement System into sub base with four-10 inch (250 mm) spikes, driven through the molded holes in the Cell frame base. The purpose of the anchoring system is to maintain cell spacing and layout during the installation of planting soil and backfill.

2. For applications where cells are installed over waterproofed structures, develop a spacing system consistent with requirements of the waterproofing system. Do not use anchoring nails that will come within 6” or less of any waterproofing material.

I. Install the second layer of Modular Suspended Pavement System frames on top of the first layer. Comply with manufacturer’s requirements to correctly register and connect the Cell frames together.
J. Register each frame on top of the lower frame post. Rotate each frame registration arrow in the opposite direction from the frame below to assure that connector tabs firmly connect. Each frame shall be solidly seated on the one below.

K. Build layers as stacks of frames set one directly over the other. Do not set any frame half on one Cell frame below and half on an adjacent frame.

L. Install Strongbacks on top of the Modular Suspended Pavement System frames prior to installing planting soil and backfill.
   1. Strongbacks are required only during the installation and compaction of the planting soil and backfill.
   2. Strongbacks should be moved as the work progresses across the installation.
   3. Strongbacks shall be removed prior to the installation of Modular Suspended Pavement System decks.

M. Install planting soil, geogrid and backfill as indicated on the drawings. The process of installation requires that these three materials be installed and compacted together in several alternating operations to achieve correct compaction relationships within the system.

N. Where required, place the geogrid curtain along the outside of the limit of the Modular Suspended Pavement System frames.
   1. Geogrid curtains are required between the edge of the Modular Suspended Pavement Systems and any soils to be compacted to support paving beyond the area of Modular Suspended Pavement Systems. Do not place geogrid curtains between the edge of the Cells and any planting area adjacent to the Cells.
   2. Pre-cut the geogrid to allow for 6 inches (150 mm) minimum under lapping below backfill, and 12 inches (300 mm) minimum overlapping top of Modular Suspended Pavement System stack.
   3. Where Modular Suspended Pavement System layout causes a change direction in the plane of the geogrid, slice the top and bottom flaps of the material so that it lies flat on the top of the cell deck and aggregate base course along both planes.
   4. Provide a minimum of 300 mm (12 inch) overlaps between different sheets of geogrid.
   5. Place the geogrid in the space between the Modular Suspended Pavement System frames and the sides of the excavation. Attach the geogrid to the Modular Suspended Pavement System frames using 3/16 inch x 14-inch (5x350 mm) zip ties. Attach with zip ties at every cell and at Cell Deck.

O. Install no more than two layers of Modular Suspended Pavement System frames before beginning to install planting soil and backfill. Compact the planting soil within the Modular Suspended Pavement System frames and the backfill material outside the frames in alternating lifts until the desired elevations and density is achieved in both planting soil and backfill.

P. Install and compact backfill material in the space between the Modular Suspended Pavement Systems and the sides of the excavation in lifts that do not exceed 8 inches (200 mm).
   1. Compact backfill to 95% of maximum dry density using a powered mechanical compactor. Use a pneumatic compacting tool or narrow foot jumping jack compactor for spaces less than 12 inches (300 mm) wide and a 12-inch wide jumping jack compactor or larger equipment in wider spaces.
   2. Maintain the geogrid curtain between the Modular Suspended Pavement Systems frames and the backfill material.
   3. Install backfill in alternating lifts with the planting soil inside the Modular Suspended Pavement Systems.

Q. Fill the first layer or layers of frames with planting soil, specified in Section 32 94 56 Planting Soil for Modular Suspended Pavement Systems.
1. Bring planting soil to the site using equipment and methods that do not overly mix and further damage soil peds within the soil mix. Soil mixes shall not be blown or pumped into the Cells using soil blowing equipment.

2. Install in lifts that do not exceed 16 inches (400 mm). Lightly compact the soil inside the frames at each lift to remove air pockets and settle the soil within the frames.

3. Do not compact greater than 80% of maximum dry density. Check the soil compaction with a penetrometer or densiometer to achieve similar compaction levels provided in the mock up.

4. If the planting soil becomes overly compacted, remove the soil and reinstall. Use hand tools or other equipment that does not damage the Modular Suspended Pavement System frames.

5. Do not walk directly on horizontal beams of the frames.

6. Work soil under the horizontal frame beams of the second level of Cell frames and between columns eliminating air pockets and voids. Fill each frame such that there is a minimum of 10 inches (250 mm) of soil over the top of horizontal frame beams before beginning compaction.

7. The top 1-2 inches (25-50 mm) of each frame post should remain exposed above the soil to allow the placement of the next frame or deck.

R. After the first two layers of Modular Suspended Pavement System frames have been installed, filled with planting soil and backfilled, proceed to install the third layer, if required, of Modular Suspended Pavement Systems frames. Comply with manufacturer’s requirements to correctly register and connect the Cell frames together.

S. Remove the strongbacks. Sweep any soil from tops before adding the next layer of frames.

T. Register each frame on top of the lower frame post. Rotate each frame registration arrow in the opposite direction from the frame below to assure that connector tabs firmly connect. Each frame shall be solidly seated on the one below.

U. Build layers as stacks of frames set one directly over the other. Do not set any frame half on one Cell frame below and half on an adjacent frame.

V. Install Strongbacks on top of third layer of Modular Suspended Pavement Systems.

W. Continue to install and compact the specified planting soil within the Modular Suspended Pavement System frames and the backfill material outside the frames in alternating lifts until the desired elevations and density is achieved in both soils.

X. Obtain final approval by the Owner's Representative of soil installation prior to installation of the Modular Suspended Pavement System deck.

Y. Remove Strongbacks after planting soil and backfill has been compacted to the top of the entire set of Modular Suspended Pavement Systems.

Z. Install 3 inches (75 mm) of compost, or leave 1-inch (25 mm) air space, below Modular Suspended Pavement System Deck as indicated on the drawings.

3.8 IRRIGATION SYSTEM INSTALLATION

A. Install irrigation as shown and per project specifications. Irrigation shall be installed within the entire soil system, under both pavement and metal grate systems.

3.9 MODULAR SUSPENDED PAVEMENT SYSTEM DECK INSTALLATION

A. Install the Modular Suspended Pavement System Decks over the top of each frame stack. Clean dirt from the tops of the Modular Suspended Pavement System frame columns. Register the deck and make connections as recommended by the manufacturer to secure the deck to the top of the Modular Suspended Pavement System Frame. Secure each deck at the four corners with screw fasteners as recommended by the manufacturer. Assure that each deck is seated firmly on the frame top with all connectors attached.
B. Install and compact remaining backfill material such that the soil outside the limits of the Modular Suspended Pavement Systems is flush with the top of the installed deck.

3.10 INSTALLATION OF GEOTEXTILE, GEOGRID, INSPECTION RISER FOR SOIL, AND AGGREGATE OVER THE DECK

A. Overlap geogrid from the sides of the Modular Suspended Pavement Systems over the top of the Modular Suspended Pavement System Decks, with minimum of 12 inches (300mm) overlap.

B. Place geotextile over the top of the deck and where indicated on the drawings, extending beyond the outside edge of the excavation by at least 18 inches (450 mm). Any joints must be overlapped by a minimum of 18 inches (450 mm).

C. Install inspection risers for soil above geotextile as indicated on drawings.
   1. Cut PVC pipe to fit vertically from Modular Suspended Pavement System deck to finish surface.
   2. Align riser with slots in Modular Suspended Pavement System deck or as shown.
   3. Wrap pipe in geotextile and secure with zip ties. Cut geotextile to overlap deck minimum 12".
   4. Cut geotextile inside the pipe to allow access. Do not cut or otherwise damage Modular Suspended Pavement System deck.
   5. Install painted caps on top of each riser flush with final paving surface.

D. Install the aggregate base course (including aggregate setting bed if installing unit pavers) over the geotextile immediately after completing the installation of the fabrics and inspection risers. Work the aggregate from one side of the deck to the other to assure that the fabric and aggregate conforms to the cell deck contours. Do not apply aggregate in several positions at the same time.
   1. Aggregate base course shall be a minimum of 4 inches (100mm) thick under pored in place concrete paving.
   2. Aggregate base course shall be a minimum of 12 inches (300mm) thick under unit pavers, asphalt paving, or porous paving.

E. Load the aggregate from equipment that is outside the limits of the excavated area. Work over material already in place.

F. For large or confined areas, where aggregate cannot easily be placed from the edges of the excavated area, obtain approval for the installation procedure and types of equipment to be used in the installation from the Modular Suspended Pavement System manufacturer.

G. Compact aggregate base course(s) in lifts not to exceed 6" in depth, to 95% of maximum dry density. Utilize a roller or plate compactor with a maximum weight of 1000 pounds. Make sufficient passes with the compacting equipment to attain the required compaction.

3.11 INSTALLATION OF PAVING ABOVE THE MODULAR SUSPENDED PAVEMENT SYSTEM

A. Place paving material over Modular Suspended Pavement System per project specifications. Take care when placing paving or other backfill on top of Modular Suspended Pavement System not to damage the system components.

B. Turn down edge of all concrete paving to Cell deck along the edges of all planting areas to retain the aggregate base course.

3.12 INSTALLATION OF BRIDGING SLABS (WHERE APPLICABLE)

A. Bridging slabs are to be used in locations where spacing larger than 3 inches (75 mm) is necessary between Modular Suspended Pavement System frames.

B. Replace aggregate base course material with a minimum 4 inch (100 mm) concrete slab beneath paving. The paving shall extend beyond the gap between Cells at a minimum of 24 inches (610 mm).
C. If spacing (gap) between Cells is larger than 12 inches (300 mm), the concrete slab must be increased to 6 inch (150 mm) thickness. If spacing (gap) between Cells is larger than 18 inches (450 mm), steel reinforcing shall be added to the slab. Reinforcing is to be designed by the project structural engineer. In no case shall the space between Cells be greater than 30 inches (750 mm).

3.13 INSTALLATION OF ROOT BARRIERS
   A. Install root barrier in accord with manufacturer's reviewed installation instructions.

3.14 INSTALLATION OF PLANTING SOIL WITHIN THE TREE PLANTING AREA
   A. Prior to planting trees, install additional planting soil, to the depths indicated, within the tree opening adjacent to paving supported by Modular Suspended Pavement Systems.
   B. Remove all rubble, debris, dust and silt from the top of the planting soil that may have accumulated after the initial installation of the planting soil within the Modular Suspended Pavement Systems.
   C. Assure that the planting soil under the tree root ball is compacted for the entire soil depth to 85-90% to prevent settlement of the root ball.
   D. The planting soil within the tree opening shall be similar in texture to the soil in the adjacent Modular Suspended Pavement Systems.

3.15 REPAIR OF CUT GEOTEXTILE
   A. In the event that any geotextile over subgrades or the Modular Suspended Pavement System decks must be cut during or after installation, repair the seam with a second piece of geotextile that overlaps the edges of the cut by a minimum of 12-inches in all directions prior to adding aggregate material.

3.16 PROTECTION
   A. Ensure that all construction traffic is kept away from the limits of the Modular Suspended Pavement Systems until the final surface materials are in place. No vehicles shall drive directly on the Modular Suspended Pavement System deck or aggregate base course.
   B. Provide fencing and other barriers to keep vehicles from entering into the area with Modular Suspended Pavement System supported pavement.
   C. Maintain a minimum of 4 inches (100 mm) of aggregate base course over the geotextile material during construction.
   D. When vehicle must cross Modular Suspended Pavement Systems that does not have final paving surfaces installed, use construction mats designed to distribute vehicle loads to levels that would be expected at the deck surface once final paving has been installed. Use only low impact track vehicles with a maximum surface pressure under the vehicle of 4 pounds per square inch, on top of the mats over Modular Suspended Pavement Systems prior to the installation of final paving.

3.17 CLEAN UP
   A. Perform cleanup during the installation of work and upon completion of the work. Maintain the site free of soil and sediment, free of trash and debris. Remove from site all excess soil materials, debris, and equipment. Repair any damage to adjacent materials and surfaces resulting from installation of this work.

END OF SECTION
SECTION 329456 - PLANTING SOIL FOR MODULAR SUSPENDED PAVEMENT SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Labor, materials, tools, supplies, equipment, facilities, transportation and services necessary for, and incidental to performing all operations in connection with furnishing, and delivery of planting soil and/or the modification of existing site soil for use as planting soil within the Silva Cell system.

B. The scope of Work in this Section includes, but is not limited to, the following:
   1. Locate, purchase, deliver and install imported planting soil and soil amendments.
   2. Harvest and stockpile existing site soils suitable for planting soil.
   3. Modify existing stockpiled site soil.

C. Related Requirements:
   1. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to Work of this Section.
   2. Section 01 33 00 – Submittal Procedures: For administrative and procedural requirement processing of submittals during the construction phase.
   3. Section 01 77 00 – Closeout Procedures: For administration and procedural requirements for completion of the Work.
   4. Section 32 90 00 Planting
   5. Section 32 94 51 Modular Suspended Paving System

1.2 PRICE AND PAYMENT PROCEDURES

D. Unit Prices: Provide unit prices for the following:
   1. Soil Unit Price 1: Remove existing site soil scheduled or otherwise shown for reuse in Silva Cells, and substitute unscreened planting soil specified in Section 32 94 56 - Planting Soil for Silva Cells, including removal of existing site soil determined unsuitable for reuse, and installation of new materials.

1.3 REFERENCES

E. Definitions:
   1. COMPACTION: The density of soil measured as oven dry weight divided by volume.
   2. EXISTING SOIL: Mineral soil existing at the locations of proposed planting of area designated for the installation of Silva Cells after the majority of the construction within and around the planting or Silva Cell site is completed and just prior to the start of Work to excavate the soil.
   3. PED: Clump or clod of soil held together by a combination of clay, organic matter, and fungal hyphae, retaining the original structure of the harvested soil.
   4. SCREENED SOIL: Soil that has been processed through a metal screen to remove or break apart soil peds (clumps/clods), roots, rocks and debris and remove larger physical items in the soil not permitted by the specification.
   5. SILVA CELLS: Structural paving support system defined in Section 32 94 51 Silva Cells.
   6. SUBGRADE: Surface or elevation of subsoil remaining after completing excavation, or
top surface of fill or backfill, before placing planting soil.

F. Reference Standards:

1. ASTM International (ASTM)

2. The Soil Science Society of America.

3. United States Composting Council [www.compostingcouncil.org and

4. United States Department of Agriculture, Natural Resources Conservation Service
      http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_054242

1.4 Submittals

G. Action Submittals: Submit in accordance with Section 01 33 00

A. Action Submittals: Submit for review and acceptance not less than 45 days prior to start of
   installation of materials and products specified in this Section.

1. Product Data: For each type of product, submit manufacturer's product literature
   with technical data sufficient to demonstrate that the product meets these
   specifications.
   a. For each compost product submit the manufactures certification that the
      compost meets the requirements for US Compost Council STA/TMECC criteria
      for “Compost as a Landscape Backfill Mix Component” and other requirements
      of the Specification.
   b. For coarse sand product submit the following analysis by a recognized
      laboratory:
      1) pH
      2) Manufactures Fines Modulus Index
      3) Particle size distribution (percent passing the following sieve sizes):
         3/8 inch  (9.5 mm)
         No 4    (4.75 mm)
         No 8    (2.36 mm)
         No 16   (1.18 mm)
         No 30   (0.60 mm)
         No 50   (0.30 mm)
         No 100  (0.15 mm)
         No 200  (0.075 mm)

2. Test and Evaluation Reports:
   a. Include analysis of bulk materials including soils and aggregates, by a recognized
      laboratory that demonstrates that the materials meet the Specification requirements.
   b. Submit required soil test analysis report for each sample of imported topsoil, existing
      site soil, and planting soil mixes from an approved soil-testing laboratory as follows:
      1) Do not submit planting soil mixes, for testing until all topsoil, compost, and coarse
         sand have been approved.
      2) If tests fail to meet the Specifications, obtain other sources of material, retest and
         resubmit until accepted by the Owner's representative.
3) All testing shall be performed following the requirements of *Methods of Soil Analysis*, The Soil Science Society of America.

4) Provide a particle size analysis (percent dry weight) and USDA soil texture analysis. Soil testing of planting soil mixes shall also include USDA gradation distribution of gravel, coarse sand, medium sand, and fine sand in addition to silt and clay. Reports of particle size distribution shall use USDA size nomenclature and analysis protocols.

5) Provide the following other soil properties:
   a.) pH and buffer pH.
   b.) Percent organic content by oven dried weight.
   c.) Nutrient levels by parts per million including: phosphorus, potassium, magnesium, manganese, iron, zinc and calcium. Nutrient test shall include the testing laboratory recommendations for supplemental additions to the soil for optimum growth of the plantings specified.
   d.) Soluble salt by electrical conductivity of a 1:2 soil water sample measured in Milliohm per cm.

6) All soil testing will be at the expense of the Contractor.

3. Samples:
   a. Each sample shall be double bagged packaged in two plastic zip loc style bags. Each bag shall be clearly marked with the project name, date, contractors name and telephone number, and product name.
   b. Samples of all existing site soil, topsoil, coarse sand and, compost and planting soil mixes shall be submitted at the same time as the particle size and physical analysis of that material.
   c. Samples of the existing site soil that are under existing pavement to be removed may be submitted as soon as possible after the paving is removed.
   d. Samples will be reviewed for appearance only.
   e. Provide samples for the following products.
      1) One-gallon (3.79-liter) sample of each type of existing site soil prior to adding amendments.
      2) One-gallon (3.79-liter) sample of imported topsoil.
      3) One-gallon (3.79-liter) sample of compost.
      4) One-gallon (3.79-liter) sample of coarse sand.
      5) One-gallon (3.79-liter) sample of unscreened planting soil mix.
      6) One-gallon (3.79-liter) sample of screened planting soil mix.

4. Qualification Statements:
   a. Soil supplier:
      1) Submit documentation of the qualifications of the planting soil supplier and their field supervisor, sufficient to demonstrate that both meet the requirements specified in Article 1.05 QUALITY ASSURANCE.
      2) Submit list of completed projects of similar scope and scale demonstrating capabilities and experience.

1.5 QUALITY ASSURANCE

B. Supplier: Soil mixes shall be supplied by a firm that specializes in the production of mixes of planting soils and have at least 5 years experience in providing soil mixes soils to projects of similar size and scope to this Work.

C. Soil Testing Laboratory Qualifications: The testing laboratory shall specialize in agricultural soil testing and be a member of the Soil Science Society of America's, North American Proficiency Testing Program (NAPT). Testing results for soil particle size shall be reported using USDA sizes for sand, silt, and clay.
1.6  DELIVERY, STORAGE, AND HANDLING

D. Weather: Do not mix or deliver soil when frozen or muddy.
E. Protect soil and soil stockpiles, from wind, rain and washing that can erode soil or separate fines and coarse material, and contamination by chemicals, dust and debris that may be detrimental to plants or soil drainage. Confine delivered materials to neat piles in areas coordinated with the site supervisor. Cover stockpiles with plastic sheeting or fabric at the end of each Workday.
F. All manufactured packaged products and material shall be delivered to the site in unopened containers and stored in a dry enclosed space suitable for the material and meeting all environmental regulations.
   1. Biological and chemical additives shall be protected from extreme humidity, cold, or heat. All products shall be freshly manufactured and dated for the year in which the products are to be used. Chemical amendments shall have original labels intact and legible, stating the guaranteed chemical analysis.

PART 2  - PRODUCTS

2.01  EXISTING SITE SOIL

A. Existing site soil: Soil at the site that is of a texture and chemical composition that can support roots provided that compost and or fertilizer is added and the soil compaction loosened.
B. Existing site soil shall meet the following criteria:
   1. Soil objects larger than 1/4 inch (6.24 mm) in diameter: Existing site soil shall contain less than 5 percent total volume of the combination of all objects 1 to 8 inches (25 mm – 200 mm) in their largest dimension including clumps/clods of heavy clay, sandy clay or silty clay subsoil, debris, refuse, roots, stones, sticks, brush, and or litter. The soil shall contain less than 8 percent by volume total of the above objects 1/4 inch (6.24 mm) to 1 inch (25 mm) in diameter. Remove objects larger than 8 inches (200 mm) in its longest dimension.
   2. Seedlings that germinated from seeds in the soil shall be removed within one month of germination whether during the period the soil is being stored or after installation including during the plant warranty period.
   3. The Owner’s Representative shall verify that the soil in the designated areas is suitable at the beginning of planting bed preparation Work. The decisions to specify the use of existing site soils is based on assumptions made during the design phase about the quality of soil which may have been covered by paving at that time or where construction activity earlier in the Project may have altered this soil.
      a. Areas and depths to which existing site soil can be harvested for use in the Silva Cells is indicated on the soil plan.
   4. Soil testing results and soil observation notes that describe the preconstruction soil conditions in the existing soil areas are included as an appendix to this Specification:
C. If the Owner’s Representative determines the soil to be unacceptable or the Work of this Project has damaged areas designated for use as existing site soil to the point where the soil is no longer suitable to support the plants specified, the Owner’s Representative may require modification of the damaged soil up to and including removal and replacement with soil of equal quality to the soil that existed prior to construction.
   1. Examples of damage include further compaction, contamination, grading, creation of hardpan or drainage problems, or lack of previously assumed O, A and or B-horizon soils.
   2. Do not begin Work on additional modifications or soil replacement until changes, if any, to the Contract price are approved.
D. Protect existing soil from contamination, and degradation during the construction process.
E. Excavation and storage of existing site soil:
   1. Remove existing plants, roots, stumps, paving, and non-soil debris from the surface layers of the soil.
   2. Excavate the soil over the areas and depths indicated on the plan or as directed by the Owner’s Representative. Utilize techniques and equipment that retains peds (clumps/clods) of soil.
   3. During the excavation process, soils in the approved areas and depths of different color and texture should be loosely mixed to create a more uniform single soil while still retaining soil peds (clumps/clods). The Owner's Representative may request that soils encountered that are not in accordance with the soil assumptions not be included in the mixing process. Such soils should be removed from the site or may be used as fill soils if approved by the Owner’s Representative.
   4. Do not screen the soil unless approved in advance by the Owner’s Representative. Encountered volumes of soil that do not meet the requirement for soil objects larger than 1/4 inch (6.24 mm) in diameter should be segregated during the excavation process and removed from the site. If approved, soil may be screened through a 2-inch (50 mm) square or larger opening in order to allow the soil to meet the requirements. Isolated large objects shall be removed from the soil by hand.
   5. Stockpile the soil in locations approved in advance by the General Contractor.

F. Amending existing site soil:
   1. Amendments for existing site soil should be calculated for a composite mix of all soils to be used.
   2. Add compost to existing site soil, up to 20 percent by moist volume to bring soil organic matter to a minimum of 3 percent by dry weight.
      a. Each 10 percent moist volume of added compost is assumed to raise the percent dry weight soil organic matter by 1.5 percent.
      b. Spread compost over the stockpile in amounts that achieve the required organic matter content. As soil is being scooped from the pile to bring to the Silva Cells, mix the compost loosely into the soil with the loader bucket. Add additional compost to the stockpile as the Work progresses to achieve even compost distribution within the mix.
      c. Do not over mix the soil. Maintain as many large soil peds (clumps/clods) as possible in the mix.
   3. Add fertilizer of the types and quantity recommended by the soil test at the time of mixing.

G. Submittal Requirements: Provide a one-gallon (3.79-liter) sample of each type of existing site soil prior to adding amendments with testing data that includes recommendations for compost volumes and chemical additives for the types of plants to be grown. Samples and test samples shall represent the composite mixing of the available soils. Samples and testing data shall be submitted at the same time.

2.02 IMPORTED TOPSOIL

A. Imported topsoil: Fertile, friable soil loam topsoil suitable for the germination of seeds and the support of vegetative growth meeting the following criteria:
   1. Soil texture: USDA loam, sandy clay loam or sandy loam with clay content between 15 and 35 percent; a combined clay/silt content of no more than 60 percent; and sand between 35 and 65 percent.
   2. Except where noted, imported topsoil shall NOT have been screened and shall retain soil peds (clumps/clods) larger than 2 inches (50 mm) in diameter throughout the stockpile after harvesting.
      a. Light screening through a 2-inch (50 mm) square or larger opening will be permissible in soils with clay content of 20 percent or greater if required to break up large peds (clumps/clods) or remove coarse roots and stones.
      b. Retained soil peds (clumps/clods) shall be the same color on the inside as is visible on
the outside surface of the ped.

3. Soil objects larger than 1/4 inch (6.24 mm) in diameter: Imported topsoil shall contain less than 5 percent total volume of the combination of all objects 1 to 8 inch (25 mm to 200 mm) in their largest dimension including clumps/clods of heavy clay, sandy clay or silty clay subsoil, debris, refuse, roots, stones, sticks, brush, and or litter. The soil shall contain less than 8 percent by volume total of the above objects 1/4 inch to 1 inch (6.24 mm to 25 mm) in diameter. Remove all objects larger than 8 inch (200 mm) in its longest dimension.
   a. Meet the above requirement by utilizing acceptable soils sources rather than soil screening.

4. Imported topsoil may be a harvested soil from fields or development sites or purchased from suppliers who collect and process soil. The organic content and particle size distribution shall be the result of natural soil formation. Manufactured soils where sand, composted organic material or other additives have been added to the soil to meet the requirements of imported topsoil shall not be acceptable.

5. pH value shall be between 5.5 and 7.5.
7. Soluble Salt Level: Less than 2 mmho/cm.
8. Soil nutrient chemistry suitable for growing the plants specified or after modification.
9. Germinating seedlings from seeds in the soil shall be removed within one month of germination whether during the period the soil is being stored or after installation, including during the warranty period of the plants.

B. Stockpiled existing topsoil at the site meeting the above criteria may be acceptable.
C. Submittal Requirements: Provide a one-gallon (3.79-liter) sample from each imported topsoil source with required soil testing results. The sample shall be a mixture of the random samples taken around the source stockpile or field. The soil sample shall be delivered with soil peds (clumps/clods) intact that represent the size and quantity of expected peds (clumps/clods) in the final delivered soil. The sample shall represent the expected amount of objects larger than 1/4 inch (6.24 mm).

2.03 COARSE SAND

A. Clean, washed, natural sand, free of toxic materials.
1. Coarse concrete sand, ASTM C33 Fine Aggregate, with a Fines Modulus Index of 2.8 and 3.2.
2. Coarse sand, free of limestone, shale and slate particles. Manufactured Sand shall not be permitted.
3. pH shall be lower than 7.4.
4. Provide coarse sand with the following particle size distribution:

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Percent passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8 inch (9.5 mm)</td>
<td>100</td>
</tr>
<tr>
<td>No 4 (4.75 mm)</td>
<td>95 to100</td>
</tr>
<tr>
<td>No 8 (2.36 mm)</td>
<td>80 to100</td>
</tr>
<tr>
<td>No 16 (1.18 mm)</td>
<td>50 to 85</td>
</tr>
<tr>
<td>No 30 (0.60 mm)</td>
<td>25 to 60</td>
</tr>
<tr>
<td>No 50 (0.30 mm)</td>
<td>10 to 30</td>
</tr>
<tr>
<td>No 100 (0.15 mm)</td>
<td>2 to 10</td>
</tr>
<tr>
<td>No 200 (0.75 mm)</td>
<td>2 to 5</td>
</tr>
</tbody>
</table>

B. Submittal Requirements: Provide a one-gallon (3.79-liter) sample with manufacturer's literature and material certification that the product meets the requirements.
2.04 FERTILIZER

A. If noted by the soil test recommendations, add slow-release, organic fertilizer based on soil test and plant requirements.
B. Fertilizers should NOT be added to Bio-retention soils.
C. Submittal Requirements: Provide manufacturer’s literature that the product meets the requirements.

2.05 BIOLOGICAL AMENDMENTS

A. Amendments such as Mycorrhizal additives, compost tea or other products intended to change the soil biology.

2.06 Unscreened Planting soil Mix

A. A mixture of imported topsoil, coarse sand, and compost to make a new soil that meets the Project goals for the indicated planting area.
   1. The approximate mix ratio of imported topsoil, coarse sand and compost shall be:
      
      | Mix component     | Percent by moist volume |
      |-------------------|------------------------|
      | Imported topsoil unscreened | 50 to 60 percent |
      | Coarse sand       | 30 to 40 percent       |
      | Compost           | 10 percent             |

   2. Final Tested Soil Organic Matter (OM): 2.75 to 4 percent (by dry weight loss ash burn).

B. Mix the coarse sand and compost together first and then add to the topsoil. Mix with a loader bucket to loosely incorporate the topsoil into the coarse sand/compost Mix. DO NOT OVER MIX. Do not mix with a soil-blending machine. Do not screen the soil. Peds (clumps/clods) of Soil, and loosely mixed Compost and coarse sand will be permitted in the overall mix.
C. At the time of soil installation, add fertilizer or biological amendments, if required, to the planting soil mix at rates recommended by the testing results for the plants to be grown.
D. Submittal Requirements: Provide a one-gallon (3.79-liter) sample with testing data that includes recommendations for chemical additives for the types of plants to be grown. Samples and testing data shall be submitted at the same time. The sample shall be a mixture of the random samples taken around the source stockpile or field. The sample shall be delivered with soil peds (clumps/clods) intact that represent the size and quantity of expected peds (clumps/clods) in the final delivered soil mix.

2.07 screened Planting soil Mix

A. A mixture of imported topsoil, coarse sand, and compost mixed off site to make a new soil that meets the Project goals for the indicated planting area.

   1. A mix of imported topsoil, coarse sand and compost. The approximate Mix ratio shall be:
      
      | Mix component     | Percent by moist volume |
      |-------------------|------------------------|
      | Imported topsoil screened | 40 to 45 percent |
      | Coarse Sand       | 40 to 50 percent       |
      | Compost           | 10 to 15 percent       |

   2. Final Tested Organic Matter: 3 to 4.5 percent (by dry weight loss ash burn).

   3. Final mix shall be thoroughly screened, mixed and blended.

B. At the time of soil installation, add fertilizer or biological amendments, if required, to the planting
soil mix at rates recommended by the testing results for the plants to be grown.

C. Submittal Requirements: Provide a one-gallon (3.79-liter) sample with testing data that includes recommendations for chemical additives for the types of plants to be grown. Samples and testing data shall be submitted at the same time. The sample shall be a mixture of the random samples taken around the source stockpile or field.

PART 3 - EXECUTION

3.01 INSTALLATION OF PLANTING SOIL IN SILVA CELLS

A. Refer to Section 329451 - Silva Cells

END OF SECTION
Submittal Checklist for Reference Only

Provide submittals required to the Owner’s Representative for review and approval. The Submittal process may take up to 2 months prior to installation of the Silva Cell system and should be executed as soon as possible after the Contract is awarded. Testing will be at the expense of the Contractor.

SOIL COMPONENT SUBMITTALS – SUBMITTED PRIOR TO SOIL MIXING

- **EXISTING SITE SOIL**
  - Lab analysis for physical and chemical composition
  - One-gallon (3.79-liter) sample

- **IMPORTED TOPSOIL**
  - Lab analysis for physical and chemical composition
  - One-gallon (3.79-liter) sample

- **COMPOST**
  - Manufacturer’s literature
  - Certificate of compliance with US Composting Council STA/TMECC requirements
  - One-gallon (3.79-liter) sample

- **COARSE SAND**
  - Manufacturer’s literature
  - Lab analysis for physical and chemical composition
  - Manufactures Fines Modulus Index
  - One-gallon (3.79-liter) sample

- **FERTILIZER**
  - Manufacturer’s literature

SOIL MIX SUBMITTALS

- **UNSCREENED PLANTING SOIL MIX**
  - Lab analysis for physical and chemical composition
  - One-gallon (3.79-liter) sample

- **SCREENED PLANTING SOIL MIX**
  - Lab analysis for physical and chemical composition
  - One-gallon (3.79-liter) sample
SECTION 330413 - COMMON SUBMITTAL REQUIREMENTS FOR UTILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.3 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect/Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Sustainable Design Submittals: Submittals required by Section 01813 "Sustainable Design Requirements." Submit documentation for products and materials contributing to achievement of LEED rating indicated. Sustainable Design Submittals are in addition to other submittal requirements.

E. Informational Submittals: Written and graphic information and physical samples that do not require Architect/Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

F. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.
1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect and Engineer reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Refer to Section 01330 for quantity of days allowed for review.
   2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

PART 2 - PRODUCTS

2.1 SUSTAINABLE DESIGN REQUIREMENTS

A. The District requires the Contractor to implement practices and procedures to meet the project's environmental performance goals. The Contractor shall ensure that the minimum requirements related to these goals, as defined in Section 01813 "Sustainable Design Requirements" are implemented to the fullest extent possible. Specific materials and systems have been selected to this end. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes compromise the aforementioned environmental goals and LEED certification.
PART 3 - EXECUTION

3.1 CONTRACTOR’S REVIEW

A. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

B. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

C. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

D. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal. Changes to the approved construction documents are subject to DSA review and approval, submitted by the Architect as a CCD per DSA IR A-6.

3.2 ARCHITECT/ENGINEER’S AND GENERAL CONTRACTOR’S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect’s staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.


E. Review Code meanings are as follows:
   1. Action Codes Permitting Use:
      a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
      b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
      c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect’s notations and Contract Document requirements.
3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.

1. Submittal Numbering: See below.
2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition

1. Each submittal consists of items from only ONE Specifications section.

2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.

3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

1. Action Code for Information Only:
   a. Action Code INF - Information Only: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will return without review or discard submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.

1. Do not submit Material Safety Data Sheets. They will be returned without review or discarded.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).

4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be ‘broken out’ for special handling. Arrange submittals accordingly.

C. Submittal Numbering

1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION
SECTION 331166 - WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Site water distribution system for irrigation water, domestic water and fire protection service up to 5 feet of any on-site commercial building being served.

B. Irrigation water, domestic water and fire protection water transmission or distribution system within a roadway or street right-of-way.

C. Protective coating or wrap for metallic pipe, fittings, restraining devices, and appurtenances.

1.2 RELATED SECTIONS

A. Section 312333, Utility Trenching and Backfilling.

1.3 RELATED DOCUMENTS

A. ASTM:
2. B 88: Specifications for Seamless Copper Water Tube.
3. D 1785: Specifications for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

B. AWWA:
3. C110: Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (76 mm Through 1,219 mm) for Water.
9. C200: Steel Water Pipe-6 In. (150 mm) and larger.
12. C207: Steel Pipe Flanges for Waterworks Service-Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
19. C219: Bolted, Sleeve-type Couplings for Plain-End Pipe.
24. C507: Ball Valves 6 In. Through 8 In. (150 mm Through 1,200 mm).
25. C508: Swing-check Valves for Waterworks Service, 2 In. (50mm) Through 24 In. (600 mm) NPS.
27. C510: Double Check Valve Backflow-Prevention Assembly.
28. C511: Reduced-Pressure Principle Backflow-Prevention Assembly.
33. C606: Grooved and Shouldered Joints.
34. C651: Disinfecting Water Mains.
36. C900: Polyvinyl Chloride (PVC) Pressure Pipe and Fittings, 4 In. Through 12 In. (100mm Through 300mm) for Water Distribution.
37. C901: Polyethylene (PE) Pressure Pipe and Tubing, ½ In. (13mm) Through 3 In. (76mm) for Water Service.
38. C905: Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In. (350 mm Through 1,200 mm) for Water Transmission and Distribution.
39. C906: Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) through 63 In (1,575 mm), for Water Distribution and Transmission.
40. C907: Polyvinyl Chloride (PVC) Pressure Fittings for Water – 4 In. through 8 In. (100 mm Through 200 mm).
44. M41: Ductile-Iron Pipe and Fittings.

1.4 DEFINITIONS

A. AASHTO: American Association of State Highway and Transportation Officials.
C. AWWA: American Waterworks Association
D. DI: Ductile iron.
E. DIP: Ductile iron pipe.
F. FM: Factory Mutual.
H. NSF: National Sanitation Foundation.
J. PE: Polyethylene.
K. PVC: Polyvinyl Chloride.
L. UL: Underwriters Laboratory.

1.5 SYSTEM PERFORMANCE REQUIREMENTS

A. Minimum Internal Pressures
   2. Test Pressure: 200-psi.

B. External Load: Earth load indicated by depth of cover plus AASHTO H20 live load unless indicated otherwise.

1.6 SUBMITTALS

A. Follow Submittal procedure outlined in Division 0 – General Conditions and Division 1 – General Requirements.

B. Product Data: For the following:
   1. Piping materials and fittings.
   2. Pipe couplings.
   3. Flexible pipe fittings.
   4. Restrained pipe fittings.
   5. High deflection fittings/ball joints.
   7. Flexible expansion joints.
   8. Gate valves.
  10. Check valves.
  11. Air and vacuum relief valves.
  13. Pressure reducing valves.
  14. Pressure sustaining valves.
  15. Ball valves.
  16. Fire hydrants.
  17. Post indicator valves.
  18. Fire department connections.
  20. Precast valve boxes and box covers.

C. Shop drawings: Include plans, elevations, details and attachments.
   1. Precast and cast in-place vaults and covers.
   2. Wiring diagrams for alarm devices.

D. Field test reports: Indicate and interpret test results for compliance with the Project requirements.
1.7 QUALITY ASSURANCE

A. Comply with requirements of utility supplying water. Do not operate existing valves or tap existing piping without written permission and/or presence of utility company representative.

B. Comply with the following requirements and standards:

C. Provide listing/approval stamp, label, or other marking on piping and specialties made to a specified standard.

1.8 MATERIAL DELIVERY, STORAGE AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:
1. Ensure that valves are dry and internally protected against rust and corrosion.
2. Protect valves against damage to threaded ends and flange faces.

B. Deliver piping with factory-applied end-caps. Maintain end-caps through shipping, storage and handling to prevent pipe end damage and to prevent entrance of dirt, debris and moisture.

C. Handling: Use slings to handle valves and fire hydrants whose size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. During Storage: Use precautions for valves, including fire hydrants according to the following.
1. Do not remove end protectors, unless necessary for inspection, then reinstall for storage.
2. Protection from Weather: Store indoors and maintain temperature higher than ambient dew-point temperature. Store indoors and maintain temperature higher than ambient dew point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

E. Do not store plastic pipe and fittings in direct sunlight.

F. Protect pipe, fittings, flanges, seals and specialties from moisture, dirt and damage.

G. Protect linings and coatings from damage.

H. Handle precast boxes, vaults and other precast structures according to manufacturer's written instructions.

I. Protect imported bedding and backfill material from contamination by other materials.

1.9 COORDINATION

A. Coordinate connection to existing water mains with water utility supplying water.
B. Coordinate piping materials, sizes, entry locations, and pressure requirements with building domestic water distribution piping and fire protection piping.

1.10 HAZARDOUS MATERIAL – ASBESTOS CONCRETE PIPE AND ASBESTOS CONTAINING MATERIAL

A. Asbestos cement pipe (ACP) exists within the project area and replacement of existing ACP is anticipated but shall be abandoned in place unless otherwise noted in the plans. The contractor shall make every attempt to protect all asbestos containing items during the execution of this contract. However, there will be instances where ACP or asbestos containing material will need to be removed, handled, cut, disturbed, or disposed of and the contractor shall comply with all local, state and federal regulations regarding construction activities near asbestos containing materials.

PART 2 - PRODUCTS

2.1 LARGE SIZE SERVICE AND DISTRIBUTION PIPES

A. PVC Pipe: Sizes 4-inch through 48-inch.
   1. Pipe:
      a. 4-inch through 12-inch: AWWA C900.
      b. 14-inch through 48-inch: AWWA C905.
   2. Fittings: DI
   3. Unrestrained Joints:
   4. Restrained Joints:
      a. Push-On Bell and Spigot Joint: Harness assembly as manufactured by Ebaa Iron (Eastland, Tx) (Tel. 800-433-1716) or approved equal.
      b. Plain End PVC to DI Mechanical Joint: Ebaa Iron (Eastland, Tx) (Tel. 800-433-1716) or approved equal.
   5. Steel or Ductile Iron Couplings:
      a. Plain End Pipe to Plain End Pipe: Ductile iron or steel bolted couplings, manufacturer's shop coating with low alloy steel bolts and nuts. Steel couplings to conform to AWWA C219. Smith-Blair, Inc, (Texarkana, AR) (Tel. 501-773-5127), Dresser (Bradford, PA) (Tel.-814-368-3131) or approved equal.
      b. Plain End Pipe to DI or Steel Flanged Pipe: Ductile iron or steel bolted flanged coupling adapters, manufacturer's shop coating with low alloy steel bolts and nuts. Steel flanged couplings to conform to AWWA C219. Smith-Blair, Inc, (Texarkana, AR) (Tel. 501-773-5127), Dresser (Bradford, PA) (Tel.-814-368-3131) or approved equal.
   6. PVC Couplings
      a. Unrestrained Plain End to Plain End Pipe: AWWA C900, as manufactured by CertainTeed (Valley Forge, PA) (Tel. 610 341-6820) or approved equal.
      b. Restrained Plain End to Plain End Pipe: AWWA C900, “Certa-Lock” as manufactured by CertainTeed (Valley Forge, PA) (Tel. 610 341-6820) or approved equal.

2.2 CORROSION PROTECTION

A. All ductile iron fittings shall be protected against corrosion with the installation of corrosion protection wrapping.
B. POLY-WRAP AND PolyETHYLENE ADHESIVE TAPE

1. Poly-wrap shall be continuous tubing formed from 8-mil (0.2-mm) thick virgin polyethylene, in accordance with AWWAC105. Minimum polyethylene tube size shall be as follows:

<table>
<thead>
<tr>
<th>PIPE SIZE POLY-WRAP FLAT TUBE WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 to 8 inches (100 to 200 mm)</td>
</tr>
<tr>
<td>(100 through 200mm)</td>
</tr>
<tr>
<td>21&quot; (530mm)</td>
</tr>
<tr>
<td>10&quot; through 12&quot;</td>
</tr>
<tr>
<td>(250 through 300mm)</td>
</tr>
<tr>
<td>29&quot; (735mm)</td>
</tr>
<tr>
<td>14&quot; through 16&quot;</td>
</tr>
<tr>
<td>(350 through 400mm)</td>
</tr>
<tr>
<td>37&quot; (940mm)</td>
</tr>
</tbody>
</table>

2. Adhesive tape shall be a general-purpose polyethylene adhesive tape, 2-inches (50-mm) wide and at least 8 mil (0.2mm) thick.

2.3 HIGH DEFLECTION FITTINGS/BALL JOINTS

A. Plain End Pipe: Xtra Flex Restrained Joint High Deflection Fittings, 4-inch through 24-inch, U. S. Pipe, (Birmingham, AL) (Tel. 205-254-7442) or approved equal.

B. Mechanical or Flanged Joint: Flex 900, 4-inch through 12-inch, Ebaa Iron Sales, (Eastland, TX) (Tel. 800-433-1716) or approved equal.

2.4 EXPANSION JOINTS

A. TR Flex Joints: TR Flex Telescoping Sleeve, 4-inch through 64 inch, U. S. Pipe, (Birmingham, AL) (Tel. 205-254-7442).

B. Mechanical or Flanged Joint: Ex-Tend 200, 4-inch through 36-inch, EBAA Iron Sales, (Eastland, TX) (Tel. 800-433-1716) or approved equal.

2.5 FLEXIBLE EXPANSION JOINTS

A. Plain End to Plain End Pipe: “Xtra Flex,” sizes 4-inch through 24-inch, U. S. Pipe, (Birmingham AL) (Tel. 205-254-7442) or approved equal.

B. Flanged or mechanical Joint: “Flex-Tend,” sizes 3-inch through 48-inch, Ebaa Iron (Eastland TX) (Tel. 800-433-1716) or approved equal.

C. Flanged Joint: Starflex, Series 500, Star Pipe Products, (Tel. 800-999-3009) or approved equal.
2.6 SERVICE LINE VALVES AND FITTINGS

A. General: AWWA C-800

B. Includes service lines, ½ inch through 2 inch, from main to meter valve, including corporation stops and curb stops.

2.7 GATE VALVES

A. Provide on lines 10-inch and smaller.

B. Valves, 3-Inch through 20-Inch: AWWA C509, resilient-seated, non-rising stem, gray or ductile-iron body and bonnet, with bronze or gray or ductile-iron gate, bronze stem and square stem operating nut unless noted otherwise. All bolts, nuts and washers, except operating nut, shall be stainless steel. Stem operating nut to be 2-inches square and open counter-clockwise. Stem extensions shall be installed to bring the stem operating nut to within 2-feet of finish grade where the depth from finish grade to the stem operating nut exceeds 4-feet. Equip valves in pump stations and other interior or vault installations with hand-wheels. Provide protective epoxy interior and exterior coating according to AWWA C550 and manufacturer’s recommendations.

C. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Mueller Company (Decatur, IL) (Tel. 800-423-1323).
   3. Clow

D. Valve Box and Cover: 9-inch minimum diameter PCC box with extensions of length required for depth of bury of valve, and cast iron or ductile iron cover with lettering “WATER”. Both the box and the cover shall be rated for AASHTO H20 loading.

2.8 AIR RELEASE, AIR/VACUUM AND COMBINATION AIR VALVES

A. AWWA C512, specific type of valve, size, details and valve box as indicated.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Apco Valves, Valve and Primer Corporation (Schaumburg, IL) (Tel. 708-529-9000).
   2. Crispin.

2.9 BLOW-OFF VALVES

A. Blow-off valve assemblies, details and boxes as indicated.

2.10 SWING CHECK VALVES

A. Valves 2-Inch through 24-Inch: AWWA C508, details as indicated.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
1. Mueller Company (Decatur, IL) (Tel. 800-423-1323).

2.11 BALL VALVES

A. Valves 6-Inch through 48-Inch: AWWA C507, details as indicated.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:

2.12 PRESSURE-REGULATING VALVES

A. Valve: Automatic, pilot-operated, cast-iron body with interior coating according to AWWA C550. 250-psi Working-pressure, bronze pressure-reducing pilot valve and tubing, and means for discharge pressure adjustment. Details as indicated.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Cla-Val Company (Newport Beach, CA) (Tel. 714-548-2201).
   2. Bermad (Porterville, CA) (Tel. 209-781-6630).
   3. Ames Company (Woodland, CA) (Tel. 916-666-2493).

2.13 FLOW-REGULATING VALVES

A. Valve: Automatic, pilot-operated, cast-iron body with interior coating according to AWWA C550. 250-psi working-pressure, bronze pressure-reducing pilot valve and tubing, and means for flow adjustment. Details as indicated.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Cla-Val Company (Newport Beach, CA) (Tel. 714-548-2201).
   2. Bermad (Porterville, CA) (Tel. 209-781-6630).
   3. Ames Company (Woodland, CA) (Tel. 916-666-2493).

2.14 SERVICE CONNECTIONS AND WATER METERS

A. Service connections and water meter details and boxes per current Contra Costa Water District standard details.

2.15 FIRE HYDRANTS

A. Wet Barrel: AWWA C503, details as indicated.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Clow (800 Series) Model 860
   2. Clow (Ranger) Model 960
   3. Jones Model J-3760
C. Available Paint Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Kelly Moore – Kel Guard Enamel “Sunburst/Safety Yellow” No 1700-63
   2. Sherman Williams – Metalex “Safety Yellow” No.B42Y37

2.16 REDUCED PRESSURE ASSEMBLY BACKFLOW PREVENTER – IRRIGATION AND DOMESTIC

A. Provide as indicated and as required by State or local agency.

B. General: AWWA C511, with OS gate valve on inlet and outlet, and strainer on inlet. Include test cocks and pressure-differential relief valve with ASME A112.1.2 air gap fitting located between 2 positive-seating check valves for continuous-pressure application.

C. Body:
   1. 2-Inch and Smaller: Bronze with threaded ends.
   2. 2-1/2-Inch and Larger: Bronze, cast iron steel, or stainless steel with flanged ends.

D. Interior Lining: AWWA C550, epoxy coating for cast iron or steel bodies.

E. Interior Components: Corrosion-resistant materials.

F. Manufacturer shall be approved by Contra Costa Water District, Materials List Attached.

2.17 DOUBLE DETECTOR CHECK BACKFLOW PREVENTER – FIRE

A. FM approved or UL listed, with OS&Y gate valve on inlet and outlet, and strainer on inlet. Include two positive-seating check valves and test cocks, and bypass with displacement-type water meter, valves, and double-check backflow preventer, for continuous pressure application.

B. Manufacturer shall be approved by Contra Costa Water District. Materials List Attached.

2.18 POST INDICATOR VALVE

A. General: UL 789, FM approved, vertical-type, cast-iron body with operating wrench extension rod, and adjustable cast-iron barrel of length required for depth of bury of valve.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Mueller Co. (Decatur, IL) (Tel. 800-423-1323).
   2. Clow Corporation (Oskaloosa, IA).

2.19 FIRE DEPARTMENT CONNECTION

A. Exposed, Freestanding Fire Department Connection: UL 405, cast brass body with threaded inlets according to NFPA 1963 and matching local fire department hose threads and threaded bottom outlet. Include lugged caps, gaskets and chains; lugged swivel connections and drop clapper for each hose-connection inlet; 18-inch high brass sleeve; and round escutcheon plate. Six 2-1/2-inch 4-way connections.
2.20 UNDERGROUND VAULTS/PITS

A. General: Portland cement concrete, precast or cast-in-place as indicated.

B. Portland Cement Concrete and Reinforcing Steel: Section 32 05 23.

C. Access Openings: As indicated.

D. External Load: Earth load plus AASHTO H20 live load if located in traffic area.

2.21 TRACER WIRE

A. General: Minimum #12 AWG stranded copper wire with blue THW, THWN, or THHN rated insulation.

2.22 WARNING TAPE

A. General: Non-detectable 3-inch warning tape made of solid blue film with continuously printed black-letter message reading “CAUTION—WATER LINE BURIED BELOW.”

2.23 PCC THRUST BLOCKS

A. Portland Cement Concrete and Reinforcing Steel: Section 32 05 23.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. General: Install pipe, fittings, and appurtenances utilizing best practices, manufacturer’s instructions, and in accordance with the following:
   1. PVC pipe: AWWA M23 and AWWA C605.

B. Pipe Depth and Trench Configuration: Conform to elevations, profiles and typical trench section(s) indicated.

C. Excavation, Bedding, Backfill, and Compaction: Section 31 23 33.

D. Handling: Carefully handle during loading, hauling, unloading and placing operations to avoid breakage or damage. Use strap type slings for lifting and placing; no chains or hooks will be permitted. Comply with manufacturer’s recommendations.

E. Laying: Before lowering pipe into the trench, remove all stakes, debris, loose rock and other hard materials from the bottom of the trench. Lay accurately in conformance with lines and grades indicated. Lay pipe on a bed of bedding material specified and prepared by handwork, dug true to grade. Furnish firm bearing for pipe throughout its entire length with bell holes provided at the ends of each pipe length of sufficient size to permit making up the particular type of joint being used. Adjust pipe to line and grade by scraping away or filling and tamping material under the body of the pipe for the entire pipe length and not by blocking or wedging. After final positioning, hold pipe in place in trench with backfill material placed equally on both sides of the
pipe at as many locations as required to hold the pipe section in place.

F. Curved Alignment: When necessary to conform to the alignment specifically indicated, lay pipe on a curved alignment by means of asymmetrical closure of joints or bending of the pipe barrel. If necessary, use shorter than the standard lengths of pipe to achieve curvature specified. Do not exceed the recommendations of the pipe manufacture for deflections at the joints or pipe bending.

G. Closure: Close open ends of pipes and appurtenance openings at the end of each days work or when work is not in progress.

3.2 CONNECTING TO EXISTING MAINS

A. Pressure Tap Connections: Perform in accordance with the requirements of the owner of the system being tapped. Maintain a positive pressure flow from the main being tapped to the tapping device to flush plastic chips, metal ribbons, etc. into the tapping devise and not into the pipe being tapped.

B. Other Connections: As indicated and in accordance with the requirements of the owner of the line being connected to.

3.3 ANCHORAGE INSTALLATION

A. Mechanically Restrained Joints: Install where indicated for lengths indicated in accordance with manufacturer’s instructions.

B. PCC Thrust Blocks: Install where required and as indicated. Bearing area indicated is to be against undisturbed earth. Allow a minimum of 24-hours curing time before introducing water into the pipeline and allow a minimum of 7-days curing time before pressure testing.

3.4 HIGH DEFLECTION FITTINGS/BALL JOINTS, EXPANSION JOINTS, AND FLEXIBLE EXPANSION JOINTS

A. Install as indicated and in accordance with the manufacturers recommendations.

3.5 VALVE INSTALLATION

A. Install all valves in accordance with the manufacturer’s instructions and the following:

1. General:
   a. Gate Valves: Appendix A of AWWA C509.

2. Joints:
   b. Valves on Steel Pipe: As indicated for buried locations. Flanged-end valves for installation in vaults/pits.

3.6 SERVICE CONNECTIONS INSTALLATION
A. Install as indicated and in accordance with the requirements of the owner of the system.

3.7 WATER METER INSTALLATION
A. Installed by Contra Costa Water District. Contractor shall coordinate installation.

3.8 FIRE HYDRANT INSTALLATION
A. Install as indicated and in accordance with the requirements of the owner of the system and the fire department.

3.9 REDUCED-PRESSURE PRINCIPLE ASSEMBLY BACKFLOW PREVENTER INSTALLATION
A. Install as indicated and in accordance with the requirements of the owner of the system and the local health department requirements.

3.10 DOUBLE CHECK DETECTOR ASSEMBLY INSTALLATION
A. Install as indicated and in accordance with the requirements of the owner of the system and the fire department.

3.11 POST INDICATOR VALVE INSTALLATION
A. Install as indicated and in accordance with the requirements of the owner of the system and the fire department.

3.12 FIRE DEPARTMENT CONNECTION INSTALLATION
A. Install as indicated and in accordance with the requirements of the owner of the system and the fire department.

3.13 UNDERGROUND VAULT/PIT INSTALLATION
A. Install as indicated.
B. Excavation and Backfill: Section 31 23 33.

3.14 TRACER WIRE INSTALLATION
A. Place and secure to top of pipe and fittings at about 3-foot intervals with 6" length of 1" wide filament tape, Scotch brand No. 898 or equal.
B. Form a mechanically and electrically continuous line throughout the pipeline, extending to the nearest valve or other pipeline appurtenance designated by the owner of the system or the Owner’s Representative. Extend the wire up the outside of the valve box/riser and cut a hole
that is 8-inches from the top, extend a 12-inch wire lead to the inside of the box. At other pipeline appurtenances, designated by the owner of the system or the Owner’s Representative, terminate the 12-inch wire lead inside the enclosure.

C. Splice wire with a splicing device consisting of and electro-tin plated seamless copper sleeve conductor. Install as recommended by the manufacturer. Wrap splices and damaged insulation with electrician’s tape.

3.15 WARNING TAPE INSTALLATION

A. Install tape approximately 1-foot above and along the centerline of the pipe.

B. Where tape is not continuous, lap tape ends a minimum of 2-feet.

3.16 PLASTIC PROTECTIVE WRAPPING FOR DUCTILE IRON PIPING

A. Cover underground ductile iron piping, including connecting galvanized steel spools, fittings, and like items with a loose, polyethylene plastic-film wrap to provide a continuous barrier between the pipe and the surrounding backfill.
   1. Wrap in accordance with AWWA-C105.
   2. Wrapping isolates the pipe surfaces from contact with corrosive environments, and is not intended to provide complete sealing or to prevent ground water intrusion.

B. Cut poly-wrap tube to a length approximately 2-feet (600-mm) longer than the length of the pipe section.
   1. Slip the poly-wrap around the pipe, centering it to provide a 1-foot (300-mm) overlap of each adjacent pipe section and bunching it accordion fashion until it clears the pipe ends.
   2. Lower the pipe into the trench and make-up the pipe joint with the preceding section of pipe. Make a shallow bell hole at joints to facilitate installation of the poly-wrap.

C. After completing the joint, make the overlap.
   1. Pull the bunched-up poly-wrap from the preceding length of pipe, slip it over the end of the new length of pipe, and secure it in place with two circumferential turns of tape plus enough overlap to assure firm adhesion.
   2. Slip the end of the poly-wrap from the new pipe section over the end of the first wrap until it overlaps the joint at the end of the preceding length of pipe.
   3. Tape it in place using three circumferential turns of tape. Take up the slack width to make a snug, but not tight, fit along the barrel of the pipe, securing the fold as necessary with adhesive tape at approximately 3-foot (900-mm) centers.

D. Repair any rips, punctures, or other damage to the poly-wrap with short length of poly-wrap tube cut open, wrapped around the pipe, and secured with tape.

E. Wrap the next section of pipe in the same manner.

F. Cover bends, reducers, and offsets with poly-wrap in the same manner as the pipe.

G. Wrap valves and other odd-shaped pieces, that cannot practically be wrapped in a tube, with a flat sheet obtained by splitting open a length of poly-wrap tube.
   1. Pass the flat sheet under the valve and bring it up around the body of the stem.
   2. Make the seams by bringing the edges together, folding over twice, and taping down. Slack width and overlaps at joints shall be handled as described above.
3. Tape poly-wrap securely in place at valve stem and other penetrations.

H. Where poly-wrapped pipe joins a pipe that is not poly-wrapped, extend the poly-wrap tube to cover the unwrapped pipe a distance of 2 feet (600-mm), unless shown otherwise on the drawings. Secure the end with at least three circumferential turns of tape.

3.17 HYDROSTATIC PRESSURE AND LEAKAGE TEST

A. General:
1. Provide all necessary materials and equipment, including water.
2. Backfill all trenches sufficient to hold pipe firmly in position.
3. Allow time for thrust blocks to cure prior to testing.
4. Flush all pipes prior to testing to remove all foreign material.
5. Perform pressure and leakage test concurrently.
6. Test pressure: See Subsection titled “System Performance Requirements.”
7. Apply test pressure by means of a pump connected to the pipe.
8. Base test pressure on the elevation of the lowest point in the line.
9. Fill each closed valve section or bulk-headed section slowly. Expel air from section being tested by means of permanent air vents installed at high points or by means of temporary corporation cocks installed at such points. Remove and plug the temporary corporation cocks at the conclusion of the test.
10. Allow water to stand in the pipe for 24 hours before test pressure is applied.
11. Allow the system to stabilize at the test pressure before conducting the leakage test.
12. Do not operate valves in either the opening or closing direction at differential pressures above the valves rated pressure.
13. Maintain test pressure as specified for type of pipe being tested.
14. Pressure Test: Examine any exposed pipe, fittings, valves, hydrants and joints during the test, if no leaks are observed the section of line has passed the pressure test. If leaks are observed, repair any damaged or defective pipe, fittings, valves, or hydrants, and repeat the pressure test.
15. Leakage Test: Perform as specified hereafter for the type of pipe being installed.

B. DIP Leakage Test: Perform in accordance with AWWA C600. Selected requirements of AWWA C600 are repeated as follows:
1. Maintain the test pressure, +/- 5 psi, for a minimum of two hours.
2. No piping will be accepted if the leakage is greater than that determined by the following formula:

\[ L = \frac{S \times D \times P^{1/2}}{133,200} \]

- \( L \) = Allowable leakage, gallons per hour.
- \( S \) = Length of pipe tested, feet.
- \( D \) = Nominal diameter of pipe, inches.
- \( P \) = Average test pressure during the leakage test, pounds per square inch (gauge).

C. PE Pipe Leakage Test: [The following leakage test for PE water pipe was taken from the Phillips Petroleum Company (Richardson, TX) (Tel. 800 527 0662) catalog for “Driscopipe.”]
1. Apply the test pressure and allow the pipe to stand, without makeup pressure, for sufficient time to allow for diametric expansion or pipe stretching to stabilize, approximately
two to three hours.

2. After the above stabilization has occurred, return the section being tested to the test pressure. Hold the test pressure for one to three hours. If the pressure in the test section drops, and it is determined the drop may be the result of expansion resulting from increasing temperature, a limited amount of additional water may be added to bring the pressure back to the test pressure. Allowable amounts of make-up water, to compensate for expansion due to increasing temperature, are as shown in the following table. Make-up water is only allowed during this final test period and not during the initial stabilization described in the previous paragraph. If the additional water added is less than the allowable shown in the table and there are no visual leaks or significant pressure drops, the tested section passes the test.

<table>
<thead>
<tr>
<th>Nominal Pipe Size (in.)</th>
<th>Allowance for Expansion in U.S. Gals./100 Feet of Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-Hour</td>
</tr>
<tr>
<td>3</td>
<td>0.10</td>
</tr>
<tr>
<td>4</td>
<td>0.13</td>
</tr>
<tr>
<td>6</td>
<td>0.30</td>
</tr>
<tr>
<td>8</td>
<td>0.50</td>
</tr>
<tr>
<td>10</td>
<td>0.75</td>
</tr>
<tr>
<td>11</td>
<td>1.0</td>
</tr>
<tr>
<td>12</td>
<td>1.1</td>
</tr>
<tr>
<td>14</td>
<td>1.4</td>
</tr>
<tr>
<td>16</td>
<td>1.7</td>
</tr>
<tr>
<td>18</td>
<td>2.2</td>
</tr>
<tr>
<td>20</td>
<td>2.8</td>
</tr>
<tr>
<td>22</td>
<td>3.5</td>
</tr>
<tr>
<td>24</td>
<td>4.5</td>
</tr>
<tr>
<td>28</td>
<td>5.5</td>
</tr>
<tr>
<td>32</td>
<td>7.0</td>
</tr>
<tr>
<td>36</td>
<td>9.0</td>
</tr>
<tr>
<td>40</td>
<td>11.0</td>
</tr>
<tr>
<td>48</td>
<td>15.0</td>
</tr>
</tbody>
</table>

D. PVC Pipe Leakage Test: Perform in accordance with AWWA M23. Selected requirements of AWWA M23 are repeated as follows:

1. Maintain the test pressure, +/- 5 psi, for a minimum of two hours.
2. No piping will be accepted if the leakage is greater than that determined by the following formula:

\[ L = \frac{(N \times D \times P^{1/2})}{7,400} \]

L = Allowable leakage, gallons per hour.
N = Number of joints in the length of the pipeline tested.
D = Nominal diameter of pipe, inches.
P = Average test pressure during the leakage test, pounds per square inch (gauge).

E. Cement Mortar Lined and Coated Steel Pipe Leakage Test: Perform in accordance with AWWA M11. Selected requirements of AWWA M11 are repeated as follows:

1. Maintain the test pressure, +/- 5 psi, for a minimum of two hours.
2. There shall be no significant leakage for pipe with welded joints or mechanical couplings.
3. For pipe joined with O-ring rubber gaskets, a leakage of 25 gallons per inch of diameter
per mile per 24-hours is allowed.

3.18 DISINFECTION

A. All New Pipelines shall be disinfected in accordance with one of the three methods specified in AWWA C651 and the following:
   1. Disinfect after pressure and leakage test have been performed and accepted.
   2. The method used shall be at the Contractor's option, unless specified by the owner of the water system.
   3. Engage the services of a commercial testing laboratory, approved by the owner of the water system, to perform the bacteriological tests specified in Section 5.1 of AWWA C651. Direct the testing laboratory to send the original report of the bacteriological testing to the owner of the water system. Should the laboratory report show that any sample taken was not acceptable, repeat the sterilization process shall until a satisfactory sterilization is accomplished.
   4. Lawfully dispose of the chlorinated water.

END OF SECTION
SECTION 334100 - STORM DRAINAGE SYSTEM

PART 1 - GENERAL

1.1 SUMMARY
   A. Provide and install all appurtenances as necessary to complete the storm drainage system, as shown on the plans, including piping and joints, flexible joints, manholes, catch basins, drain inlets, and area drains.

1.2 RELATED SECTIONS
   A. Section 31 23 33, Utility Trenching and Backfill

1.3 RELATED DOCUMENTS:
   A. AASHTO:
      1. M 199: Precast Reinforced Concrete Manhole Sections.
   B. ASTM:
      1. A615/A615M: Deformed and Billet-Steel Bars for Concrete Reinforcement.
      2. C 443: Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
      6. D 1785: Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
     10. F 477: Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
   C. AWWA:
      3. C110: Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (76 mm Through 1,219 mm) for Water.
D. Caltrans Standard Specifications
   1. Section 52 Reinforcement
   2. Section 65 Reinforced Concrete Pipe

1.4 REGULATORY REQUIREMENTS:
   A. City of San Pablo, Standard Specifications and Details.
   B. Contra Costa County Flood Control District, Standard Specifications and Details.

1.5 Definitions
   A. AASHTO: American Association of State Highway and Transportation Officials.
   D. HDPE: High-density polyethylene.
   E. NPS: Nominal pipe size.
   F. PVC: Polyvinyl chloride.
   G. RCP: Reinforced concrete pipe.

1.6 SUBMITTALS
   A. Submittal procedure shall be as outlined in Division 1 – General Requirements.
   B. Product Data Shop Drawings, etc. for the following:
      1. Piping materials and fittings.
      2. Special pipe couplings.
      4. Plastic area drains.
      5. Cleanout plugs or caps.
      6. Precast manholes
      7. Precast concrete catch basins, inlets, curb inlets, junction structures and area drains, including frames and grates.
      8. Precast clean out boxes and box covers.
   C. Design Mix Reports and Calculations: For each class of cast in place concrete.
   D. Field Test Reports: Indicate and interpret test results for compliance with performance.

1.7 DELIVERY, STORAGE AND HANDLING
   A. Do not store plastic structures, pipe and fittings in direct sunlight.
B. Protect pipe, fittings, and seals from dirt and damage.

C. Handle precast concrete pipe, manholes and other precast structures according to manufacturer’s written instructions.

D. Protect imported bedding and backfill material from contamination by other materials.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS FOR GRAVITY FLOW

A. PVC Pipe and Fittings: Pipes 12” and smaller in diameter shall be SDR 26 PVC conforming to ASTM D3034 using elastomeric gasket joint in a bell and spigot assembly system or as shown on plans. Minimum 2 feet cover, maximum 15 feet cover.

1. Fittings: Shall conform to ASTM F 1336.

B. Reinforced Concrete Pipe: Pipes greater than 12” in diameter shall be Class III, Type II Portland Cement conforming to ASTM C76 and C150 or as shown on plans.

C. HDPE Pipe and Fittings: (As alternate to PVC only) pipes can be HDPE (High Density Polyethylene Pipe) DR-11 (160 psi), conforming to ASTM F714 and AASHTO designation M-294.

D. Manholes

1. General:
   a. Size, shape, configuration, depth, etc. of manhole and frame and cover shall be as indicated.

2. Portland Cement Concrete and Reinforcing:
   a. Poured-in-Place Portion: Section 03 30 00 – Portland Cement Concrete.
   b. Precast Portion:
      1) Pre-cast Concrete manhole conforming to ASTM C478 and shall be Type II modified cement with a minimum compressive strength of 4,000 psi at 28 days. Iron Castings for manhole covers and frames shall conform to ASTM A48, Class 25
      2) ASTM C 478. Rate for AASHTO H20 loading in traffic areas.

3. Frames and Covers: As indicated and in accordance with Caltrans Standard Specification Section 75-1.02.

4. Steps: Manufacture from deformed, ½-inch steel reinforcement rod complying with ASTM A 615/A 615M and encased in polypropylene complying with ASTM D 4101. Include pattern designed to prevent lateral slippage off step.

   a. Acceptable manufacturers include:
      1) Hanson Concrete Products, (Milpitas, CA) (Tel 408-262-1091)
      2) Or approved equal.

E. Concrete Trench Drains

1. Modular system of concrete channel sections, grates, and appurtenances; designed so
grates fit into channel recesses without rocking or rattling. Include number of units required to form total length required.

2. Include the following components:
   a. Channel Sections: Interlocking-joint, precast modular units with end caps. Inside width as indicated with deep, rounded bottom, with built in slope or flat invert as indicated and outlets in number, sizes, and locations indicated. Include extension sections necessary for required depth.
   b. Frame and Grate: Ductile iron as indicated. Where drain is located in traffic areas, rate for AASHTO H20 loading.

3. Locking Mechanism: Manufacturer’s standard device for securing grates to channel sections.

4. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   a. “Polydrain” by ABT Inc. (Troutman, NC) (Tel 704-528-9806).
   b. “ACO Drain” by ACO Polymer Products Inc. (Chardon, OH) (Tel. 800-543-4764).
   c. Or approved equal.

F. Cleanouts
   1. Piping: Same as storm drain line if possible.
   2. Top Plug or Cap: Same material as piping if possible. Plug or cap to be secure but removable, threaded or non-threaded.
   3. Box Size: As required to provide access and allow easy removal and reinstallation of plug or cap.
   4. Box Types:
      b. Traffic Areas: Portland cement concrete box and box cover or steel or cast iron cover, heavy duty, both box and cover to be rated for AASHTO H20 loading.
   6. Available Manufacturers: Subject to compliance with requirements, box manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
      a. Associated Concrete Products, Inc. (Santa Ana, California) (Tel. 714-557-7470).
      b. Brooks Products Inc. (El Monte, California) (Tel. 818-443-3017).
      c. Christy Concrete Products, Inc. (Fremont, California) (Tel. 800-486-7070).

G. Area drains shall only be used on 6 inch in diameter or smaller storm drain lines.
   1. Area drains shall be polyvinyl chloride.
   2. Grates shall be brass and comply with accessibility requirements.
   3. Rate for AASHTO H20 loading in traffic areas.

H. Catch Basins shall be pre-cast or cast-in-place with 3,000 psi concrete and 1-1/2 inch max aggregate size.

I. Frames, Grates and Covers for Catch Basins: Caltrans Standard Specification Section 75-1.02, 75-1.03 and 75-1.05.
   1. Galvanize steel frames, grates and covers.
   2. Grates and covers shall be non-rocking.
   3. Rate for AASHTO H20 loading in traffic areas.
2.2 Special Pipe Couplings
   1. Gravity Piping: ASTM C 1173. Rubber or elastomeric sleeve and band assembly fabricated to match outside diameters of pipes to be joined.

2.3 Joint sealant for precast structures and manholes
      1. Use to seal around pipes at connections to structures and manholes. Also use to seal joints between precast sections of structures and manholes.
   B. Gaskets: Preformed flexible rubber or plastic gasket.
      2. Plastic Gaskets: Federal Specification SS-S-00210 (GSA-FSS), Type I, Rope Form; or alternate standard which may exist.

PART 3 - EXECUTION

3.1 GRAVITY PIPE INSTALLATION
   A. Construct all storm drainage utilities to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations.
   B. Install pipe, fittings, and appurtenances utilizing best practices, manufacturer’s instructions, and in accordance with Section 6 and 7 of ASTM D 2321 for plastic pipe, Caltrans Standard Specification Section 65-1.07 for reinforced concrete pipe, and chapter 11.3.3 of AWWA M41 for cast iron and ductile iron pipe.
   C. Pipe Depth and Trench Configuration: Conform to typical trench section(s) indicated.
   D. Excavation, Bedding, Backfill, and Compaction: Section 31 23 33 – Utility Trenching and Backfill
   E. Handling: Carefully handle during loading, hauling, unloading and placing operations to avoid breakage or damage. Use strap type slings for lifting and placing; no chains or hooks will be permitted. Comply with manufacturer’s recommendations.
   F. Laying: Before lowering pipe into the trench, remove all stakes, debris, loose rock and other hard materials from the bottom of the trench. Lay accurately in conformance with lines and grades indicated. Start laying the pipeline at the low end and proceed upstream. Lay bell and spigot pipe with the bell end facing upstream. Lay pipe on a bed prepared by handwork, dug true to grade. Furnish firm bearing for pipe throughout its entire length with bell holes provided at the ends of each pipe length of sufficient size to permit making up the particular type of joint being used. Adjust pipe to line and grade by scraping away or filling and tamping material under the body of the pipe for the entire pipe length and not by blocking or wedging. After final positioning, hold pipe in place in trench with backfill material placed equally on both sides of the pipe at as many locations as required to hold the pipe section in place.
   G. Curved Alignment: When necessary to conform to the alignment specifically indicated, lay pipe on a curved alignment by means of asymmetrical closure of joints or bending of the pipe barrel.
Use shorter lengths of pipe than the standard length if necessary to achieve curvature specified. Do not exceed the recommendations of the pipe manufacture for deflections at the joints or pipe bending.

H. Closure: Close open ends of pipes and appurtenance openings at the end of each days work or when work is not in progress.

3.2 SPECIAL PIPE COUPLINGS

A. General: Use where required to join piping and no other appropriate method is specified. Do not use instead of specified joining methods.

B. Installation: Manufacturer’s instructions.

3.3 CLEANOUT INSTALLATION

A. General: Install as indicated.

3.4 INSTALLATION OF CURB INLETS, CATCH BASINS, DROP INLETS, JUNCTION STRUCTURES, AREA DRAINS, ETC. AND MANHOLES

A. Excavation, Bedding, Backfill, and Compaction: Section 31 23 33 – Utility Trenching and Backfill

B. Poured in Place Structures: Install as indicated and Caltrans Standard Specification Section 51.
   1. Shape bottoms to convey flows as indicated.

C. Precast Structures: Install as indicated.
   1. Seal all joints and pipe entrances and exits.
   2. Place concrete in bottom and shape to convey flows as indicated.

3.5 CONCRETE TRENCH DRAIN INSTALLATION

A. Excavation, Bedding, Backfill, and Compaction: Section 31 23 33 – Utility Trenching and Backfill

B. Install: As indicated and in accordance with the manufacturer’s instructions.

C. Valve shall be installed in accordance with manufacturer’s written Installation and Operation Manual and approved submittals.

3.6 TRENCHING AND EXCAVATION

A. Existing PCC or AC Areas: Cut PCC or AC to full depth at a minimum distance of 12-inches beyond the edge of the trench.

B. Excavate by hand or machine. For gravity systems begin excavation at the outlet end and proceed upstream. Excavate sides of the trench parallel and equal distant from the centerline of
the pipe. Hand trim excavation. Remove loose matter.

C. Excavation Depth for Bedding: Minimum of 4-inches below bottom of pipe or as otherwise allowed or required by the District’s Representative, except that bedding is not required for nominal pipe diameters of 2-inches or less.

D. Excavation Width at Springline of Pipe:
   1. Up to a nominal pipe diameter of 24-inches: Minimum of twice the outside pipe diameter, or as otherwise allowed or required by the District.
   2. Nominal pipe diameter of 30-inches through 36-inches: Minimum of the outside pipe diameter plus 2-feet, or as otherwise allowed or required by the District.
   3. Nominal pipe diameter of 42-inches through 60-inches: Minimum of the outside pipe diameter plus 3-feet, or as otherwise allowed or required by the District.

E. Over-Excavations: Backfill trenches that have been excavated below bedding design subgrade, with approved bedding material.

F. Comply with the District limitations on the amount of trench that is opened or partially opened at any one time. Do not leave trenches open overnight without the approval of the District.

G. Where forming is required, excavate only as much material as necessary to permit placing and removal of forms.

H. Bottoms of trenches will be subject to testing by District. Correct deficiencies as directed by the District.

I. Grade bottom of trench to provide uniform thickness of bedding material and to provide uniform bearing and support for pipe along entire length. Remove stones to avoid point bearing.

3.7 BACKFILLING

A. Backfill per Section 31 23 33: Utility Trenching and Backfill.

3.8 CLEANUP

A. Upon completion of utility earthwork all lines, manholes catch basins, inlets, water meter boxes and other structures shall be thoroughly cleaned of dirt, rubbish, debris and obstructions of any kind to the satisfaction of the District.

3.9 TESTING

A. General: Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
   1. Do not enclose, cover, or put into service before inspection and approval.
   2. Test completed piping systems according to authorities having jurisdiction.
   3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours advance notice.
   4. Submit separate reports for each test.
   5. Where authorities having jurisdiction do not have published procedures, perform tests in accordance with latest edition of the Uniform Plumbing Code (UPC) Section 1109.0,
Testing.
6.Leaks and loss in test pressure constitute defects that must be repaired.
7.Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

B. Storm Drain Pipe:
1. Storm drain pipe, shall be hydrostatically joint tested, (air test is not to be used), in the field for water-tightness in accordance with ASTM Standard C 1103.
2. Perform test after pipe is bedded but prior to any backfill.
3. Testing may be done by manufacturing pipe with double gasket joints, or by utilizing a joint tester. Contractor shall obtain the District’s Representative’s approval of details of the Contractor’s selected method prior to performing the testing.
4. Inspect all joints for leakage.
5. If the pressure holds, or drops less than 1psi in 5 seconds, the joint is acceptable.
6. After backfill of storm drain, the Contractor shall video inspect the pipeline. The video shall be supplied to the District for review.

3.10 DISPOSAL
A. Lawfully dispose of all unsuitable and excess or surplus material off-site at no cost to the District.

3.11 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL
A. Construction Waste shall be managed in accordance with provisions of Standard Construction Waste Management and Disposal Practices. Documentation shall be submitted to satisfy the requirements of that section.

END OF SECTION